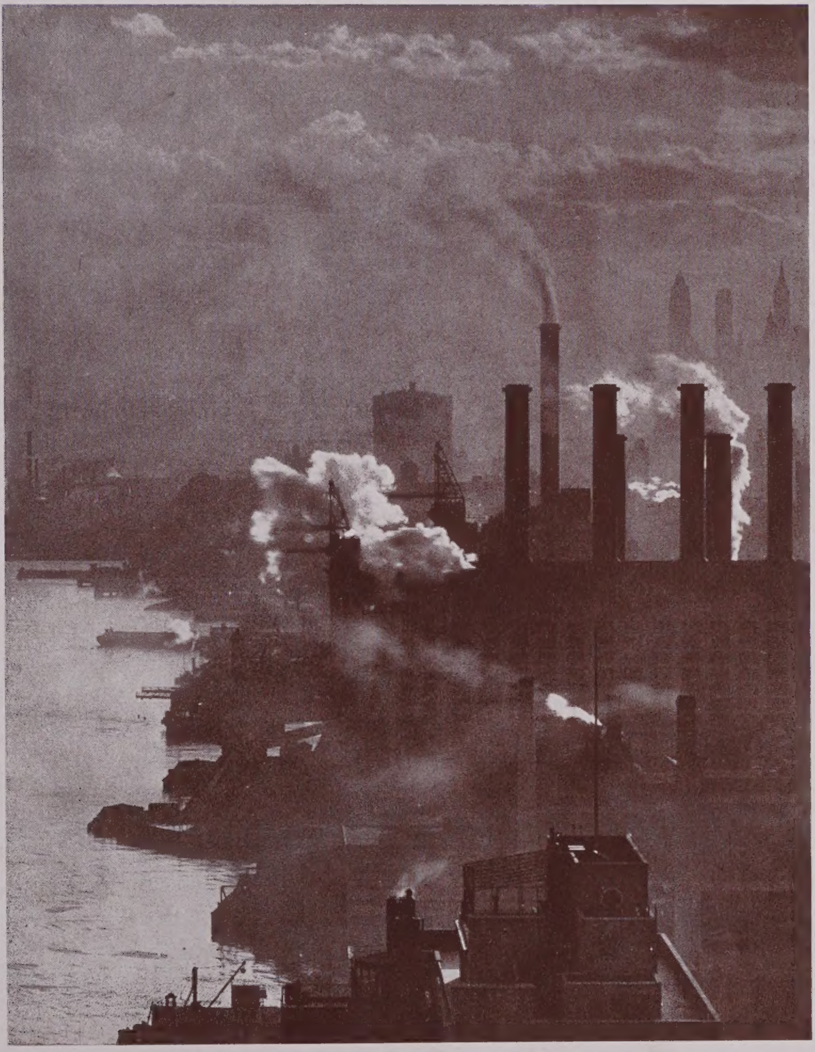
Electrical Engineering

May
1932



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American Institute of Electrical Engineers

Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Cleveland, Ohio	June 20-24, 1932	Summer Convention	(Closed)
Vancouver, B. C.	Aug. 30-Sept. 2, 1932	Pacific Coast Convention	May 30, 1932
Baltimore, Md.	October 10-13, 1932	District Meeting	July 10, 1932
Memphis, Tenn.	November, 1932 (CANCELLED)	District Meeting	CANCELLED
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	Oct. 23, 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science	Syracuse, N. Y.	June 20–25	A. L. Elder, Syracuse Univ., Syracuse, N. Y.
American Society of Civil Engineers	Yellowstone National Park	July 6–9	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Soc. of Mech. Engrs. Aeronautic Division	Buffalo, N. Y.	June 6–8	C. W. Rice, 29 W. 39th St., New York, N. Y.
American Soc. of Mech. Engrs. semi-annual convention	Lake of Bays, Ontario, Can.	June 21–July 1	C. W. Rice, 29 W. 39th St., New York, N. Y.
American Society for Testing Materials	Atlantic City	June 20–24	Am. Soc. for Test. Mtls , Phila., Pa.
Canadian Electrical Association	Murray Bay, Quebec, Can.	June 15–17	B. C. Fairchild, 409 Power Bldg., Montreal, Can.
Illuminatimg Engineering Society	Swampscott, Mass.	Sept. 26–Oct. 1	E. H. Hobbie, 29 W. 39th St., New York, N. Y.
International Electrical Congress	Paris, France	July 5–12	Harold Pender, Univ. of Pa., Phila. Pa.
N.E.L.A. annual convention and exhibit	Atlantic City, N. J.	June 6–10	A. J. Marshall, 420 Lexington Ave., New York, N. Y.
National Electrical Manufacturers Assn.	Hot Springs, Va.	May 15–20	A. W. Berresford, 420 Lexington Ave., New York, N. Y.
N.E.L.A. East Central Division	Toledo, Ohio	May 24–27	D. L. Gaskill, 603 Broadway, Greenville, Ohio
N.E.L.A. Middle West Division	Kansas City, Mo.	May 18–20	Thorne Browne, 1527 Sharp Bldg., Lincoln, Neb.
N.E.L.A. New England Division	Bretton Woods, N. H.	July 11–13	Miss O. A. Bursiel, 20 Providence St., Boston, Mass.
N.E.L.A. Pacific Coast Electrical Assn.	Pasadena, Calif.	June 14–17	K. I. Dazey, 447 Sutter St., San Francisco, Calif.
South American Electrotechnical Congress	Buenos Aires, Argentina	July 4–11	R. F. Ascher, Secy., Paseo Colon 185, Buenos Aires, S. A.

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This Month—

Front Cover

The East River at dusk, a less familiar portion of New York City's widely publicized skyline, showing the Waterside steam-electric generating stations of the New York Edison Company (6 stacks), one of the plants of the New York Steam Corporation (tallest stack), and a glimpse of three of the financial district's monuments in the background.

Photo by Samuel H. Gottscho, Jamaica, N. Y.

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Short Items—

DEVELOPMENT of a high degree of reliability in the low-voltage a-c. network required the development of a network protector having special characteristics. Various methods of obtaining these characteristics are used by the different manufacturers. *p. 307–312*

MORE ACCURATE calculation of conditions on power systems after the occurrence of a fault now can be made by the use of revised standard decrement curves developed jointly by General Electric and Westinghouse engineers. *p. 324–329*

ELIMINATION of a series of severe arc-overs caused by lightning surges entering a distribution substation has been secured by shunting low voltage lightning arresters across the regulator series winding and by connecting lightning arresters at the substation end of the entrance cable. *p. 304–306*

CLEVELAND, Ohio, "the forest city" situated on the south shore of Lake Erie, will be host to the summer convention of the Institute June 20–24, 1932. In addition a most complete technical program, many vacation features and novel entertainments are being arranged. There will be no registration fee. *p. 346–348*

MANY interesting discussions took place at the recent meeting of the Institute's Great Lakes District in Milwaukee, Wis., March 14–16, 1932. The principal of these are summarized in this issue. *p. 348–350.* The concluding section of summaries of winter convention discussions also is given. *p. 350–353*

INTEREST in the "Letters to the Editor" section is constantly growing, and members are taking advantage of this opportunity to express themselves briefly and informally on a variety of topics. *p. 354–355*

ONE ASPECT of the banking and investment situation is stated clearly in an editorial recently printed in *Engineering News-Record*. Bankers, it is claimed, are responsible for the failure of many investments abroad, due to their unwillingness to take advantage of expert engineering advice. *p. 353–354*

GAS FILLED tubes have characteristics which make them adaptable to many rectifier, inverter, and control applications. Also, the capacity of the electron tube has been increased manyfold by filling with gas or vapor, and the sensitivity by which these tubes may be controlled is being developed constantly. *p. 312–318*

THE PART that engineering and engineers may play in the stabilization of industry is discussed in the tenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" contributed by William Green, president of the American Federation of Labor. *p. 318–319*

AN INNOVATION has been introduced by the use of alternating current for the operation of supervisory control systems. Furthermore, these systems may possess great reliability, and arrangements may be made for the operator to visualize switching conditions at a glance. *p. 329–331*

ELECTRICAL and magnetic units are being subjected to careful scrutiny at all times; they are discussed in four articles presented in this issue. *p. 335–345*

PARAGUTTA, an improved insulating material for submarine communication cables, has made it possible to obtain three telephone channels in a cable but little larger than the older single-channel gutta-percha cables. *p. 332–335*

OPEN-CIRCUIT remanence of a permanent magnet and the manner in which it is affected by various factors is a study of prime importance to magnet manufacturers and users. These factors include the magnetic properties of the steel itself and the shape and size of the magnet, all of which can be controlled in the design and manufacture. *p. 320–323*

Weather Resistant Covering for Line Wires

Previous to the last two years, development of weather resistant covering for line wires lay in the hands of the manufacturer and was centered upon meeting the demand for a cheaper product. This resulted in a decreasing life of the covering. Research described in this article points the way to a greatly improved covering which, although slightly more expensive to produce, can be justified economically by its longer life and higher insulating quality. Specifications for the saturant of such a covering are presented herewith.

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DURING the years following 1918 or 1920 effort was concentrated upon the reduction of cost of weather resistant covering for line wires. This resulted in the early loss of saturating compound and the shedding of braids, in many cases within a period of two or three years after the erection of the lines. Sentiments of many operating engineers therefore swung toward discontinuing a weather resistant covering on overhead lines and adopting bare conductors for all service except where tree wire was necessary or where highly insulated conductors were required at points of inadequate spacing or clearance.

Certain engineers opposed the policy of abandoning the use of weather resistant coverings on overhead lines having a line-to-line voltage of 4,000 or less, for the reason that such a covering might reduce the number of service interruptions by preventing grounds and short circuits. This group believed that an attempt should be made to improve weather resistant coverings before making a decision to discontinue their use. At the suggestion of engineers in the group of companies represented on the Utilities Research Commission, the latter initiated a study at Purdue University to develop weather resistant wire covering providing longer life and higher insulating value. This study was started October 1, 1929, under the direction of the electrical division of the engineering experiment station with the chemical division cooperating. Work already completed enables the following definite conclusions to be drawn:

1. The present triple braid weatherproof wire covering may be materially improved by using as saturants higher fusing-point blown asphalts, free of waxes, and of low boiling fluxes. Such saturants will provide a covering of uniformly long life.

2. These improvements can be secured at only a slightly increased cost.

3. The higher saturating temperatures required to apply such saturants may be used without damage to the cotton yarns and without excessive annealing of the copper conductors.

4. As a result of this work, a preliminary specification for the saturant of weatherproof coverings is presented in this article, and includes terms which guarantee weatherproof wire of long life.

5. Future work will provide a covering of lighter weight and smaller size, but of higher insulating value and longer life than present construction.

Economic studies have proved that these results justify an increased cost of weather resistant wire covering, provided the improvements of higher insulating value and longer life now available are incorporated during manufacture.

Preliminary Specification for Weatherproof Wire Saturant

The saturating compound shall consist of a pure blown petroleum asphalt and shall not be mixed with any material such as paraffin, wax tailings or fluxes. It shall have the following physical properties:

Ball and Ring Fusing Point: 180–200 deg. fahr.

Penetration: 77 deg. fahr., 100 g., 5 sec., 35 or harder, tenths of mm.

Pliability: A mold of the asphalt $^1/_4$ x 1 x 4 in. shall not break when subjected to an angle of bending of 15 deg. around a mandrel of $^3/_{16}$ in. radius at a temperature of 0 deg. fahr. This test shall be made in the Reeve and and Yeager pliability testing equipment, at a rate of bending of 10 deg. per min.

Loss by Evaporation: A 100 g. sample of the compound heated for 100 hrs. at a temperature of 325 deg. fahr. shall not lose more than 1.0 g. in weight.

Rise in Fusing Point: The difference in the ball and ring fusing point determined before and after the above heating test shall not be greater than 40 deg. fahr.

Change in Penetration After Heating: The penetration of the sample subjected to the above heating test shall not become harder by more than 10 points. The crust formed on the sample during the heating test may be removed before determination of the penetration after heating.

Written especially for ELECTRICAL ENGINEERING, based upon "Weather Resistant Covering for Line Wires" (No. 32-56) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932, and subsequently brought up to date by the inclusion of later test results and definite specifications. *Not published in pamphlet form.*

Complete testing equipment was purchased or constructed for the laboratory at the university, as it was found that no adequate equipment was available in the plants manufacturing weather resistant wire in the United States. Accelerated weathering equipment therefore was installed for testing the comparative length of life of completed wires, asphalts, and other saturants, yarns, etc.; this exposes the samples to light from a carbon arc and to a water spray at a constant wire temperature of 175 deg. fahr. during one part of the daily weathering cycle. The samples are subjected to freezing by moving the wire holding drum to a large refrigerator and to thawing and drying by moving back to the light exposure chamber. Distilled water is circulated to the sprays from a storage tank and pressure provided by an auxiliary pump.

A natural weathering rack for completed wires provides continuous current loading and application of line voltage to the wire samples. Service testing equipment for duplicating installation and service conditions includes apparatus for subjecting the wire

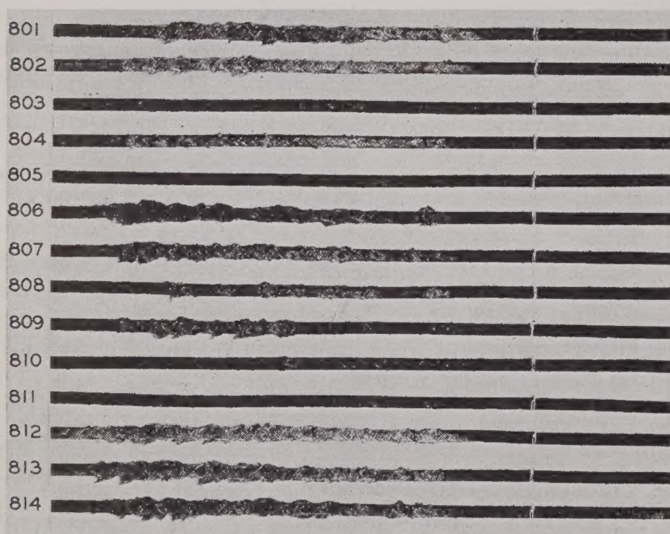

Fig. 1. Condition after accelerated weathering test of wires saturated with commercial solvents

to abrasion such as occurs when drawn over a cross-arm or caused by rubbing on insulators, wrapping and bending at freezing temperatures, and for producing decentralization of the conductor in the covering as occurs in service.

Standard physical tests are applied to the saturant as follows:

1. Fusing point is determined by the standard ball and ring method used by the asphalt industry, the fusing point being the temperature at which a steel ball of specified weight drops through a mold of the material under test, the material being supported on a brass ring and immersed in water, the temperature of which is raised at a slow and definite rate.

2. Viscosity of the asphalt at saturating temperatures is determined by the Stormer method, by which it is expressed as the number of seconds required for 100 revolutions of a cylinder propelled by a 100-g. weight and immersed in the material to be tested.

3. Consistency or hardness is determined by use of the Abraham consistometer; this equipment measures the pressure required to force the various sized plungers at a constant rate into the material under test. Hardness is also measured by the needle penetrometer commonly used by the asphalt industry. By this method the hardness is the depth of penetration into the asphalt, expressed in tenths of millimeters, of a standard needle with a weight of 100 g. applied for 5 sec. The lower the penetration number the harder is the material. In Table I, hardness is expressed in terms of penetration.

4. Pliability at low temperatures is determined by bending a mold, of dimensions $^1/_4 \times 1 \times 4$ in., broadside about a round mandrel $^3/_8$ in. in diameter while the sample and apparatus are held at the low temperature of test. The angle of bend is increased at the rate of 10 deg. per min. and the angle of bending required to break the mold is taken as a measure of the pliability.

The designs for an improved Abraham consistometer to measure hardness, and for Reeve & Yeager pliability test equipment especially adapted to this work, have been completed. The rate of penetration in the consistometer and the rate of bending in the pliability tester will be quite constant, as both are to be electrically driven and the degree of bending in the pliability test will be determined by automatic electric timing of the start and finish of the bending period. The consistometer hardness will be read from a pressure gage which indicates the pressure on the table of the consistometer supporting the asphalt sample under test.

In the testing of finished wire a small electrically heated braid press and a pliability tester in which very small samples of asphalt may be tested have both been completed. The braid press is used to extract the saturant from the two inner braids of a finished wire. Sufficient asphalt is obtained from a 2-ft. length of No. 6 wire for the standard ball and ring melt point test and the penetration determination. With this new equipment the pliability test can be made upon the small sample extracted from the braids.

The commonly used drip and stain tests cannot be regarded as tests of the physical properties of the saturants. The high melting wax used as an outer coating prevents staining, and the yarns hold the asphalt, preventing dripping even though the saturant may be quite soft. The drip test may favor also an unsaturated wire.

Previous Production Methods

Before the start of the last decade, weatherproof wire coverings usually were built up of braids made from high-strength long-fiber cotton yarn, often saturated after each braid was applied and usually saturated with natural asphalts rather than petroleum base asphalts. Production methods were slow and the materials used more expensive than it is now possible to use. With the start of the last decade the producers of weatherproof wire began to use cheaper grades of cotton yarn and looser braids, and for saturants they turned to petroleum by-product asphalts. They further changed from the saturation of each braid after its application to the application of all three braids in one step and the saturation of these braids as a second step. To obtain the production speeds required and to saturate three braids in one step at the temperature (that of low pressure steam) available in the wire plants, the use of low melting point petroleum asphalts of low viscosity at saturating temperatures became general.

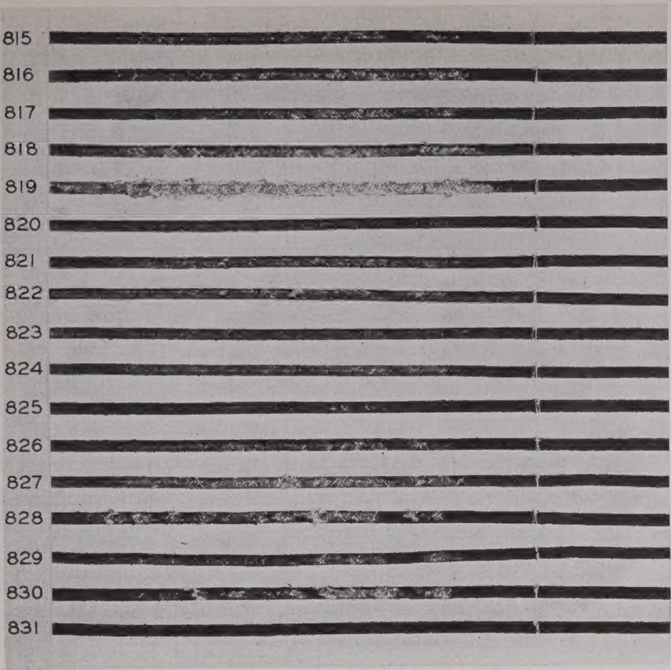

Fig. 2. Condition after accelerated weathering test of wires meeting various parts of preliminary specifications. Wires 815–8, 820–6, and 830 meet these specifications in every detail

Saturants Cause of Major Faults

The test results indicate positively that the poor physical properties of the saturants used in weather resistant wire coverings in the past have been the cause of the extremely early failure of weather resistant wire. The coverings of wires which last well are eventually caused to fail by a combination of physical changes such as the shifting of saturants in the coverings, etc., and chemical changes in the saturant caused by exposure to light, oxygen of the air, etc. In very early failures the effects of light and oxygen are of less importance than the effects of poor physical properties which cause the saturant to shift in the braid when hot, and to crack and split when cold.

These poor physical properties of the saturants are: too low fusing points, extreme softness when warm, great changes in hardness with changes in temperature, extreme brittleness at even moderately low temperatures, and a marked tendency to evaporate. The majority of saturants used have had softening points (as determined by the ball and ring method) ranging from 130 to 150 deg. fahr., which are lower than maximum wire operating temperatures. These materials shift in the braids leaving the upper braids unprotected at ordinary summer temperatures, which are well below the fusing point. The extreme brittleness of these saturants, resulting in cracking and breaking of the braids in cold weather, may be illustrated by the fact that in the pliability test at 0 deg. fahr., less than 2 deg. bending is required to break the molds of the majority of these saturants.

Many of the poor physical properties, particularly the disappearance or evaporation of the saturant from the braids, have been caused by the addition of excessive amounts of waxes, wax tailings, or low melting fluxes to obtain fluidity and ease of saturation. Usually this addition was made by the workman operating the saturating tank and resulted in a saturant of variable properties. These low boiling materials soon leave the saturant, causing the body of the asphalt to disintegrate. The saturants vary in their resistance to the weathering effects of light and oxygen, and the worst are subject to excessive surface deterioration and erosion. The result of all these factors is the loss of compound, particularly from the upper side of the braids, with the resultant breaking of the braids on the upper side and the familiar festooning.

Finishing waxes cannot be regarded as of great protection to the covering because they evaporate or crack and flake off within a short time, or are damaged in installation. On the various samples in the natural exposure rack, the wax has cracked, chipped off, or simply disappeared from the surface of the wire in from 3 to 8 months.

Cotton Yarns

It has been found that the cotton yarns are not so important in producing a long-lived covering as are the saturants. It is important, however, that sufficient cotton to absorb and hold the saturant be present in the two inner braids, and that the outer braid be closely woven to resist abrasion and erosion. The one fault of the braided construction is that because of the interstices always present it does not consistently afford insulation beyond that of the air spacing provided. It is desirable to have a more solid and homogeneous material next to the conductor.

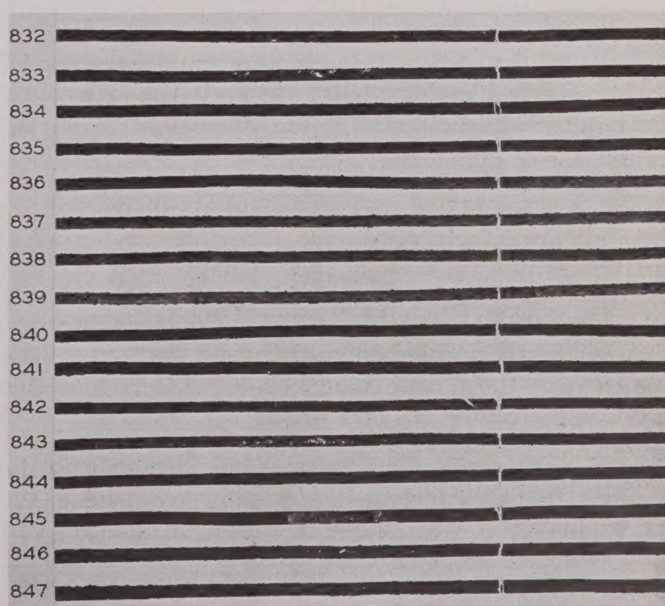

Fig. 3. Wires illustrating the improved weather resistance of air blown asphalts to which the proper inert mineral fillers have been added

Table I—Comparison of Physical Properties of Commercial Saturants and Asphalts Proposed as Saturants

	Range of Physical Properties		Average of Physical Properties	
	Commercial Saturants	Proposed Saturants	Commercial Saturants	Proposed Saturants
B. & R. fusing point				
Before heating	119–158°F	186–208°F	143.2°F	196.1°F.
After heating	176–245	209–232	198.4	220.7
Penetration: 77°F., 100 g., 5 sec.				
Before heating	3–66	21–33	25.5	27.5
After heating				
with crust	0–23	0–4	8.7	1.0
crust removed	0–26	17–29	11.8	22.3
Loss in weight during heating	0.12% gain, 7.17% loss	0.03–0.97% loss	1.63%	0.36%
Pliability	0.41°–13.3°	16.2°–48°	3.21°	26.5°
Specific gravity				
Before heating	1.001–1.200	0.987–1.044	1.071	1.011
After heating	1.021–1.208	0.988–1.042	1.080	1.013

Improved Saturants

The use, as weatherproof wire saturants, of the air blown asphalts meeting the preliminary specification which has been developed, has been proved in the laboratory to yield a greatly increased length of life of the covering on any size of wire over that provided by the usual commercial saturants, and to provide a great increase of flexibility in the finished wire. The physical properties of these asphalts and the present commercial saturants are given in Table 1. The preliminary specification also is given on p. 299.

Such an asphalt, of greater stability at higher wire temperatures, will reduce materially the shift of the saturant in the braids and will be less subject to evaporation and erosion. In addition, these asphalts are less susceptible to temperature changes and are much less brittle at low temperatures. Such asphalts may be bent many degrees in the pliability test, while most commercial saturants cannot be bent more than 2 deg.

These "air blown asphalts" are produced by blowing air through the heated petroleum residue, as compared to the production of the usual commercial saturant by blowing steam through the petroleum residue. Certain changes in the structure of the asphalt are produced by the air blowing which results in a much more stable asphalt of lower temperature susceptibility. The asphalts illustrated in Fig. 2 are stock products; they are not special materials in any sense. There is no reason to think that the increased use of air blown asphalts meeting these specifications will result in a marked increase in cost of the materials (which now cost very little more than the steam reduced asphalts) because the petroleum residue is just as readily blown to meet this specification as one of a lower melting point.

Adequate proof of the betterment obtained by the use of these materials is given by comparing the wires in Fig. 1 with those in Fig. 2, all having had the same exposure in the accelerated weathering test. Fig. 1 shows the condition of wires saturated with the present commercial saturants after having been exposed in the accelerated weathering test at Purdue. The four wire coverings that have held up well on this test are saturated with very hard and very brittle materials. The asphalts with which

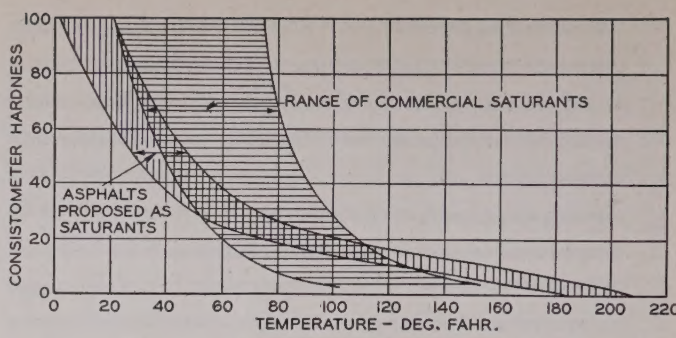

Fig. 4. Comparison of initial hardness

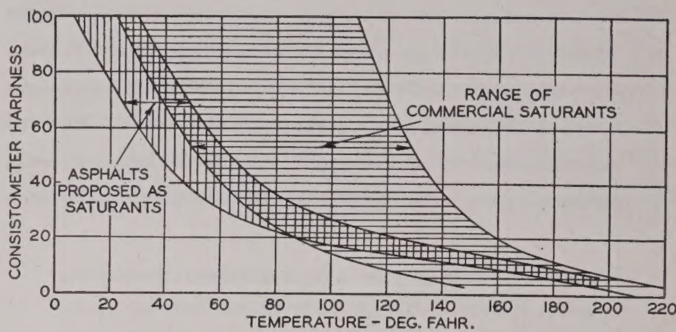

Fig. 5. Comparison of hardness of saturants after heating for 100 hr. at 325 deg. fahr.

these four wires are saturated bend less than 2 deg. in the pliability test. This emphasizes the importance of applying both the laboratory pliability test and the accelerated weathering test in choosing the most satisfactory weather resistant coverings. The wires in Fig. 2 have coverings saturated with air blown asphalts meeting the specification for melting point and penetration, but in the case of samples 819, 826–9, and 831 not meeting other parts of the specification such as those for pliability or changes in physical properties with long continued heating. It may be seen readily that the wires meeting the preliminary specification in every detail provide a vast improvement in weather resistance over the commercial saturants; these wires are numbers 815–8, 820–6 and 830. In the pliability test all of these asphalts bend more than 15 deg. and wires saturated with these materials may be bent about their own diameter at freezing, or lower in some cases, without breaking any of the braids.

Sample 819 is saturated with a material that has shown peculiar breakdown when exposed to light and heat and that has been used in the lower melting point ranges in very great quantities of weatherproof wire in the past 10 years.

The use of the asphalts meeting the preliminary specification requires only a change of saturating temperature and does provide a remarkable improvement in the weather resistance of the covering.

The smaller change with temperature in the hardness of air blown asphalts as compared with the commercial saturants, and also the greater stability at the higher operating temperatures, is illustrated in Fig. 4. It may be seen that the air blown asphalts are harder, as an average, at temperatures of 40 deg.

fahr. and higher; but are softer than the commercial saturants below this temperature. The smaller change in the hardness of the air blown asphalts as compared with the commercial saturants after being heated for 100 hr. at 325 deg. fahr. is shown in Fig. 5. It will be noted that the blown asphalts have not changed greatly, while the commercial saturants have become much harder. This lack of change with long heating has been proved to correlate rather closely with the resistance of the wire covering to weathering.

While all of the asphalts which weather poorly in the wires in Fig. 2 would have been eliminated by requiring them to meet the preliminary specification, it is not yet certain that this will always be true and the accelerated weathering test must still be depended upon to eliminate the poor materials. In the operation of the "weatherometer" on the standard cycle used by the Bureau of Standards, the commercial saturants all show extreme checking or cracking in only one day whereas the asphalts recommended show no signs of deterioration in this time except in one instance, thus checking the tests of the asphalts in wires as illustrated in Figs. 1, 2, and 3.

The analysis of asphalt and the determination of chemical unsaturation now are being carried on to learn if it is possible to correlate some result of this analysis with the variation in weathering.

Saturating Temperatures

To obtain thorough saturation of triple braid coverings with saturants of a fusing point of from 180 to 200 deg. fahr. at present saturating speeds, it is necessary to use higher saturating temperatures than are used today. Laboratory tests have shown that to obtain saturation of three braids on No. 6 AWG. conductors in 5 min. requires a saturant viscosity of 100 deg. Stormer, or less. In Fig. 6 is shown graphically the time required to saturate at any given viscosity the triple braid covering on No. 6 AWG. conductors with asphalts of a very wide range. It should be noted that the time of saturation is not the same for all saturants at a given viscosity but varies with the asphalt, some requiring more and some less time.

That higher temperatures are required to obtain saturation of the braided coverings with the air blown asphalts than are required in the case of the commercial saturants is shown in Fig. 7. Viscosities lower than 100 sec. per 100 revolutions are required to obtain saturation of triple braid coverings at present saturating speeds, and temperatures of 360 deg. fahr. and higher are necessary for saturation with these asphalts. A change would be required in the heating equipment for the saturating tanks if such saturants are to be used.

A number of tests was made to determine definitely whether or not saturating temperatures as high as 400 deg. fahr. can be used without damaging the cotton yarns or too greatly annealing the copper conductors. The cotton yarns were tested for tensile strength, heated in air for different times, allowed to regain normal moisture content, and again tested. The tensile strength of oil soaked yarns was also tested and compared with that of similar yarns heated in oil for varying times. No. 6 AWG. copper conductors, both medium hard and hard drawn, were tested for tensile strength after heating in hot oil for varying times, and compared with tests made on unheated conductors. The results of the cotton and copper tests are presented in Tables II and III.

It may be seen that the loss of strength of the cotton yarn is of no importance in even the longest saturating time. There is no appreciable annealing of the copper conductors in the saturating times required in the modern continuous saturating tanks now generally used. In the case of the older type

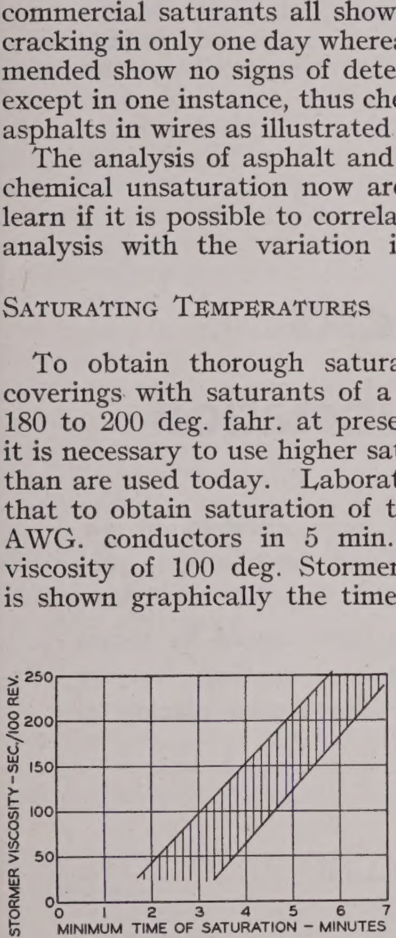

Fig. 6. (Left) Viscosity vs. saturating time for triple braid covering on No. 6 AWG. conductors

Fig. 7. (Below) Comparison of viscosity of saturants

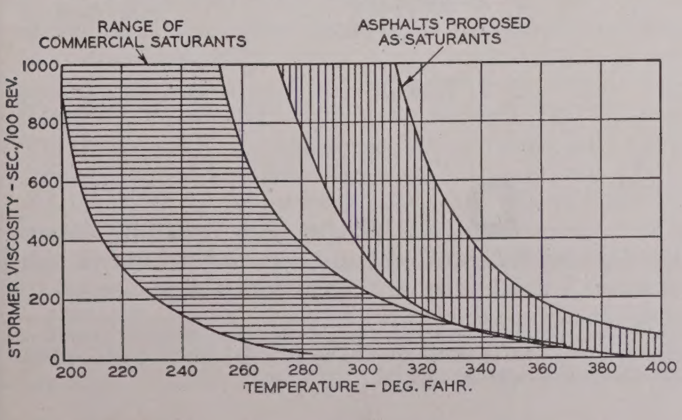

Table II—Effect of Saturating Temperature on the Tensile Strength of Cotton Yarn

Yarn Heated in Air (Constant Temperature Oven)

Sample	Tensile Strength	Loss	Per Cent Loss
Original yarn	2,001 g.		
Heated 15 min. at 392 deg. fahr.	1,760 g.	241	12.0
Heated 30 min. at 392 deg. fahr.	1,526 g.	475	23.7
Heated 90 min. at 392 deg. fahr.	1,360 g.	641	32.0

Yarn Heated in Oil

Sample	Average Tensile Strength	Per Cent Loss A	Per Cent Loss B	Per Cent Loss C
Dry yarn	1,908 g.			
Dipped in cold oil	1,917 g.			
Heated 15 min. 212 deg. fahr.	1,809 g.	5.62		
Heated 30 min. 212 deg. fahr.	1,731 g.	14.5	4.32	
Heated 15 min. 302 deg. fahr.	1,683 g.	12.2	7.00	
Heated 30 min. 302 deg. fahr.	1,623 g.	15.3	10.30	3.57
Heated 7 1/2 min. 392 deg. fahr.	1,637 g.	14.6	9.55	2.52
Heated 15 min. 392 deg. fahr.	1,593 g.	16.85	11.98	5.35
Heated 30 min. 392 deg. fahr.	1,546 g.	19.3	14.55	8.13

A Cold oiled sample as a standard
B Sample heated 15 min. at 212 deg. fahr., as a standard
C Sample heated 15 min. at 302 deg. fahr., as a standard

Table III—Effect of Saturating Temperature on the Tensile Strength of Copper Conductors

All Samples Heated at 392 Deg. Fahr.

Kind of Sample	Tensile Strength Lb. per Sq. In.	Loss in Strength Lb. per Sq. In.	Per Cent Loss
Hard drawn No. 6 copper wire			
Unheated wire	63,560		
Heated 10 min	62,590	970	1.53
Heated 30 min	61,140	2,420	3.96
Medium hard drawn No. 6 copper wire			
Unheated wire	51,430		
Heated 10 min	50,780	650	1.27
Heated 30 min	49,490	1,940	3.93

"reel in and reel out" saturating tank, the time required for saturating may be long enough to anneal the conductor slightly, requiring that the conductors be drawn somewhat harder initially. It is believed that these tests have definitely cleared the way for the use of higher saturating temperatures in so far as a likelihood of any damage to yarns or conductors is concerned.

Other Modifications

The improvement that may be made in the weather resistance of the air blown asphalts by the use of the proper inert mineral filler is shown in Fig. 3. Wires numbers 832–5 are saturated with the same materials as wires 815–8 in Fig. 2 except that 30 per cent by weight of 325-mesh slate dust was added to the asphalt before saturation. Wires 840–2 in Fig. 4 are also asphalts to which certain modifying agents have been added. The use of such modifying materials provides an additional and very desirable improvement in the weather resistance of the wire covering and also may slightly reduce the cost of the saturant because of the cheapness of the slate dust. The use of the filler is particularly helpful in the case of the asphalt on the surface of the wire and in the case of the finishing materials.

Finishing materials that are more flexible than the present waxes may be had and are much more desirable, particularly when some filler is used as a coating or an anti-stick in these finishes. Mica flake is especially valuable as an outer finish.

New and Improved Coverings

The greatly superior insulation of paper tape covered samples with a single weatherproofed outer braid has been shown repeatedly by the slower decrease in insulation resistance of this covering when immersed in water, as compared with the triple braid construction. The use of this paper tape and single braid covering provides a conductor of lighter weight and of much smaller overall diameter, which means that sleet and wind loads will be lower, and also that the conductor will possess consistently high dielectric strength even with considerable exposure of the braids to the weather. Bakelite and other synthetic resins, Harvel compounds and varnishes, and other materials, have been applied to weather resistant wire coverings, and because of the excellent weathering quality of such materials provide a highly protective coating.

Ample proof has been given that the materials recommended herewith will produce longer life in weatherproof wire coverings. Also, these materials may be obtained within a reasonable distance of any weatherproof wire plant in the United States. It is felt that the experience and equipment built up as a result of this work should prove of value in the development of improved weatherproof braids as applied to types of wire other than the ordinary weatherproof wire. This is especially apparent when it is pointed out that in looking for improved materials, the coverings of tree wires and other insulated overhead line wires were investigated to learn if the weatherproofing compounds used in the braids on these wires were superior to the ordinary weatherproofing compounds, and it was discovered that while these coverings were made of exceptionally strong and high grade braids, they were not saturated with compounds in any way superior to the present commercial weatherproof saturants.

Impulse Tests on a Substation

Severe flashovers have occurred in ungrounded 4,800-volt distribution substations in Detroit. Impulse tests have proved that these were caused by surges reflected from regulator windings, but can be prevented by the proper placing of lightning arresters.

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During the 1928 lightning season the Detroit Edison Company experienced in five substations a total of six arc-overs which were caused by

Based upon "Impulse Voltage Tests on a 4,800-Volt Distribution Substation" (No. 31-133) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., October 22–24, 1931.

lightning voltages entering the stations by way of a 4,800-volt ungrounded distribution system. The overhead lines of this system enter the substations through three-conductor underground cables, and lightning arresters are located at each junction of line to cable and at the substation bus. Some of the distribution lines are equipped with three phase voltage regulators in the substations. These regulators are Y-connected, but the neutral is not brought out and is insulated from ground. Fig. 1 shows the layout of a typical distribution line with a regulator.

Besides being unusually large in number for a single season, the arc-overs were of unexpected severity. In each case the lightning voltage causing flashover entered the substation by way of a distribution line on which there was a voltage regulator. Furthermore, the flashovers occurred at some point between the substation pothead and the line-side regulator terminals, their nature indicating that they were caused by potentials in excess of the breakdown voltages of the cable pole and bus lightning arresters, which inspection showed to be in good operating condition. This consistency in the location of the flashovers indicated that the surge impedance of the regulator series winding probably was great enough to cause reflections of surges entering the substation, and so to result in the building up of a voltage at the regulator line terminals sufficiently high to cause flashover.

As the result of a series of impulse voltage tests, two forms of protection were found to be effective in preventing the surge voltage rising to values sufficient to break down the entrance cable or cause flashovers at the station end. Low voltage lightning arresters shunted across the regulator series windings operate in series with the bus arrester and limit to the sum of the breakdown voltages of these two sets of arresters the rise of voltage on the line side of the regulator. The second method, and the one which is more desirable because of its insuring a lower voltage at the substation end of the cable, is to connect arresters at this point to ground. They limit the voltage on the substation pothead and on the regulator, and, acting in combination with the arresters on the bus and at the outside end of the cable, the voltage in the station and entrance cables to the drops across the arresters.

Equipment Used

The 4,800-volt Elmdale distribution substation is of the open pipe-frame construction, the bus copper and all leads being insulated with varnished cambric. One distribution line with voltage regulator was left in the substation, and its 745-ft. entrance cable was looped back so that both ends were in the station. This was a three-conductor, 200,000-cir. mil, lead-covered cable insulated with oil-impregnated paper $^5/_{32}$ in. thick on the conductors with a $^5/_{32}$-in. over-all belt. A dead 24,000-volt three-conductor cable line 8,900 ft. long terminated in the station and was available during the tests.

The impulse voltages used during the various tests were obtained from a 1,000,000-volt lightning generator and auxiliary equipment. Since only 180,000 volts were required in the tests, the generator was reconnected to deliver this voltage with a capacity of 0.075μf. During the tests, two portable cathode-ray oscillographs were used, one being an improved Norinder oscillograph, and the other a George oscillograph of the hot cathode type. The apparatus in the measuring system included a resistance potentiometer and a delay cable.

The substation apparatus tested is shown in Fig. 1. Pothead 1 represents the cable pole pothead of the entrance cable. It was to this pothead that the surge generator was connected by a resistance, and through it the voltage surges entered the station. It will be noted that the three phases were joined electrically by potential transformers which were connected open-delta, and by the voltage regulator which was Y-connected with neutral ungrounded. Each phase had a lightning arrester at the cable pole pothead 1 and at a point on each bus section, 6 and 7; various combinations of these arresters were tried during the tests. The arresters were rated 6,000 volts for use on an ungrounded system. Suitable lightning arresters also were available for connection at the substation pothead and for shunting the regulator series winding.

An analysis of a traveling surge entering the cable from the overhead line shows that, due to the lower surge impedance of the cable, the wave on the line will be reflected with reduced magnitude and reversed polarity. The voltage of the surge entering the cable will be less and the current greater than in

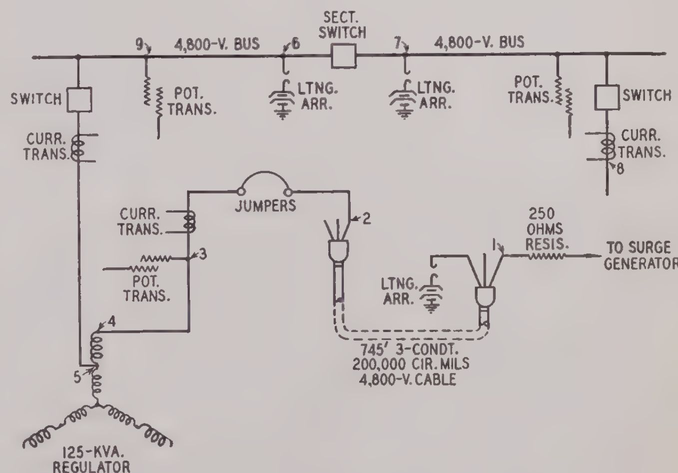

Fig. 1. Typical circuit layout at Elmdale substation, indicating points at which oscillograms of the surge voltage waves were taken

the original line surge. The following equations show these effects:

$$e = \frac{2Z_c}{Z_c + Z_L} E_L$$

$$i = \frac{e}{Z_c}$$

where

e = voltage of surge in cable
Z_c = surge impedance of cable
Z_L = surge impedance of line
E_L = voltage of surge on line
i = surge current in cable

If the surge generator should be discharged directly into the cable, the current drawn by the arresters would be excessive due to successive reflections of current. Since it was not possible to apply the surge to the cable by means of an overhead line, a resistance was placed in series with the surge generator to limit the current in the cable to a value which would approximate that of a surge entering from an overhead line. In the tests a series resistance of about 250 ohms was used.

Two general types of impulse voltage waves were used. One had a wave front with voltage rise from zero to maximum in approximately one microsecond, while the other, which was secured by connecting 1,360 millihenrys inductance in series with the surge generator, had a wave front with voltage rise to maximum in about 10 microseconds. The wave having the steep front, as nearly as rectangular as possible, was required to show clearly on the oscillogram, reflections of the impulse at the voltage regulator. Tests with surges having the slower wave fronts were also desirable in order to determine the effects of moderate surges of voltage such as may be induced on lines by nearby lightning strokes.

In the preliminary tests it was found that a number of factors which might be considered to be of importance could be neglected. For example, oscillograms taken with various values of resistance connected to the bus to simulate the effects of other circuits indicated that although the surge voltage appearing on the bus decreased as the connected resistances were decreased, the shapes of the impulse voltage waves at points 1 and 2 were unaffected. Therefore most of the tests were made with the station bus open-circuited. It was found also that although in order to simulate connection to an overhead line the two phases which were not connected to the surge generator should be grounded at 1 through a resistance having a value of about 500 ohms the oscillograms did not differ from those taken with these phases open-circuited; consequently most of the tests were made with the latter arrangement. Preliminary voltage-time oscillograms also indicated that the effects of the instrument transformers were slight and that measurements need be taken only at positions 1, 2, and 5. At these three points the oscillograms are quite different because of the effect of the cable pole lightning arresters, the cable itself, and the voltage regulator. Also the voltages induced on the two phases which were not connected to the surge generator were found to be of negligible magnitude, or usually about one-fourth of the voltage on the surged phase. Therefore further measurement of them was omitted.

The impulse voltage tests indicated definitely that only a small amount of energy was drawn from the cable through the series windings of the regulator by the lightning arresters and other equipment connected to the bus, especially for the first part of the wave. In one test a surge of about 25-kv. crest entered the cable and was increased at station pothead 2 to a crest value of about 43 kv. by the partial reflection at the voltage regulator. The positive reflected wave returned to the cable pole end where it caused sufficient voltage rise to break down the lightning arresters located there. These arresters prevented further voltage rise and returned a negative reflected wave to the station end of the cable, reducing the voltage at that point to about 23 kv. Due to the high impedance of the regulator series winding, the rise of surge voltage on the bus was much lower than at the station pothead, and the bus lightning arresters were not able to protect the cable against voltage surges which may enter the substation through it. Additional tests made with the lightning arresters at the cable pole end disconnected also indicated that the lightning arresters on the bus do not provide protection for the cable, as the regulator impedance remained very high for a period sufficient to cause a flashover at the station pothead.

Using the slow-front wave, oscillograms were taken, but these did not show the reflections at the regulator as distinctly as did those for the steep-front wave, because the entering wave does not reach its maximum at the cable pole pothead before the reflection begins to return from the regulator and adds to the voltage of the entering wave. However, if the entrance cable had been long enough to require about 10 microseconds for an impulse to travel back and forth through it, then the reflections would have been just as distinct as for the surge having a one-microsecond front. These oscillograms do show definitely that the surge voltage at the regulator rises to a value greater than that at the cable pole pothead, and the reflections at the regulator are therefore appreciable. Consequently, even with the slow-front wave, the regulator series winding offers considerable impedance and the rise of voltage on the bus is slow.

The tests showed conclusively that the lightning arresters at the cable pole end of the entrance cable only partially limit the rise of voltage at the substation end of the cable. If the front of the incident wave is short and the entrance cable long, approximately double the voltage at the cable pole end will be impressed at the station end for an appreciable time before the cable pole arresters relieve this condition.

By these tests, however, it was definitely proved that the voltage at the station pothead may be limited to a safe value by shunting low voltage arresters across the regulator series winding, thus permitting the bus arresters to help lower the voltage at this point. The rise in voltage on the line side of the regulator then is limited to the sum of the breakdown voltages of these two sets of arresters.

It was also definitely proved that protection could be secured by lightning arresters located at the substation end of the cable. These limit the voltage on the pothead and the regulator, and, in combination with the cable pole and the bus arresters, limit the voltage in the cables within the station and in all of the entrance cables to the drops across the arresters. This method of protection is more desirable than the use of low voltage arresters shunting the regulator series windings, since lightning arresters connected at the station pothead limit the voltage at that point to a somewhat lower value.

Operating Requirements of the Network Protector

Rapid extension of the low-voltage a-c. network in metropolitan areas has required the solution of a number of new problems, among them being the development of a suitable network protector consisting of circuit breaker, relays, etc., to disconnect the feeder from the network at the proper times.

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RELAY PROTECTION of the type of low voltage a-c. network installed in the metropolitan area of New York City was designed to give the a-c. network the same reliability of service obtained on a d-c. network. Such reliability was essential if the a-c. network was to be used in areas of high load density where continuity of service is of paramount importance.

Briefly, this type of a-c. network consists of a grid of three-phase four-wire low-voltage mains to which power is supplied at suitable intervals by distribution transformers connected to high voltage feeders. To obtain diversity of supply, adjacent transformers are connected to different high voltage feeders which in turn are supplied by different generator bus sections. Connecting the low voltage side of the transformers to the network are automatic network protectors which are the only means of readily disconnecting the high voltage feeders from the network.

The network protector consists of a three-pole air circuit breaker, a motor or solenoid to close the breaker against the action of springs and gravity, two relays which control the closing and opening of the circuit breaker, and fuses in series with the circuit breaker contacts to give back-up protection.

Many years' experience with the d-c. network, supplemented by test data, indicated that with sufficient power available, faults on the network would burn clear. Thus, the first requirement of the protection scheme was that all sources of power remain connected to the network during network disturbances. The next requirement was for the circuit breaker to open immediately when a fault occurred on the feeder side of the protector, either on the feeder or in a transformer connected to that feeder. In order that a high voltage feeder might be taken out of service with a minimum amount of time and expense it was considered desirable that the protector open on transformer exciting current as the station operator could then clear a feeder merely by opening the station breaker.

The closing operation also had to meet certain requirements: first, if the transformer is energized while the network is deenergized, the protector must close; second, if the network is energized but the transformer is deenergized, it must remain open; third, when both transformer and network are energized the protector must close when, but only when, the magnitude and phase relation of the transformer voltage with respect to the network voltage is such that after it has closed, power will flow to the network.

Design of Master Relay

To meet these requirements a relay usually referred to as the master relay, having three induction type, watt-hour meter elements, was provided. These elements consist of disks mounted on a single shaft between the poles of electromagnets. The connections of the Westinghouse and General Electric master relays are shown schematically in Figs. 1 and 2. Referring to the diagram of the Westinghouse relay, the lower pole of each magnet is magnetized by a potential coil, and the upper poles by either the current coils or the phasing coils. The current coils are connected to current transformers and are energized when the breaker is closed. The phasing coils are connected in parallel with the breaker contact and are energized when the breaker is open. The General Electric relay is similar except that the current coils are also the phasing coils.

The relay operates in the same manner as any directional relay. The interaction of the flux due to current in the potential coil with that due to current in either the current or phasing coils, causes the disks to rotate in one direction if the flow of power is toward the network, and in the opposite direction if the flow is toward the transformer. The relay has one moving contact actuated by the disk shaft, and two stationary contacts. Rotation of the shaft in one direction closes the closing circuit of the protector, and in the opposite direction, the tripping circuit.

When the protector is completely deenergized, the relay is held in the closing position by a spring. Because the potential coil is on the network side of the protector, no magnetic torque will be present when the transformer only is energized; and to cause a protector to close on a dead network, mechanical torque has been provided. When the network is energized but a feeder is deenergized, the

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protectors associated with it will remain open because current will flow through the phasing circuits to give, in conjunction with the potential coils, maximum opening torque.

Upon energizing the feeder the voltage across each of the circuit breakers of its associated protector becomes the vector difference between the transformer voltage and that of the network. The torque on the relay depends upon the relation of this so-called phasing voltage to the network voltage. It is desirable that the transformer voltage be somewhat greater in magnitude than the network voltage before the breaker is closed. To impose this limitation upon the operation of the relay, the potential coil flux is lagged by an adjustable shading coil or lag ring so that the potential coils alone exert an opening torque slightly greater than the closing torque of the spring. Before the relay will make its "closing" contacts this excess opening torque must be overcome by the phasing coils. The amount of phasing voltage necessary to close the breaker may be varied by adjusting the shading coils. Practise on the system of the New York and Queens Electric Light and Power Company is to set the relays to close when a phasing voltage of 2 volts exists in phase with the network voltage.

The lamps shown in the phasing circuits and usually referred to as phasing lamps are 15-watt 150-volt tungsten lamps. As tungsten has a high positive temperature coefficient, its resistance will tend to keep the current in the phasing circuit constant regardless of the voltage across it, and the coils can be made sensitive to phasing voltages of widely varying magnitudes.

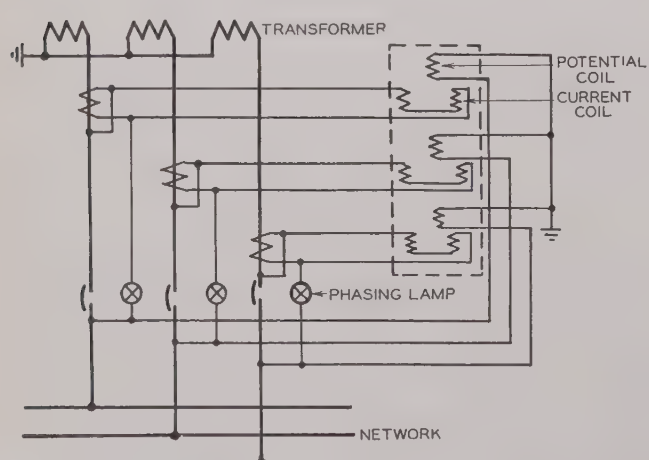
Operating Characteristics of Master Relay

The operating characteristic of a Westinghouse master relay on a 1,600-ampere (submersible rating) protector is shown in Fig. 3. Curve 1 is the locus of line currents varying in magnitude and phase angle referred to the network voltage which will produce a balanced torque on the relay element. If a vector representing current of any given magnitude and phase angle drawn from the origin crosses the curve, that current will cause the relay to close its tripping contacts and the protector will open. If the vector of the current does not cross the curve, the relay will close its closing contacts. It is evident therefore that a current of 30 amperes lagging the network voltage, reversed, by 84 deg. will produce a balanced torque in the relay. As the exciting current of a 500-kva. three-phase transformer with which such a protector is used has an exciting current of approximately 30 amperes at an angle of less than 80 deg., as indicated by the vector I_E, the relay will cause the protector to open when exciting current only is flowing. Curve 2, which is curve 1 redrawn to a smaller scale, shows that for currents not exceeding 4,000 amperes the relay acts like the usual watt element, the characteristic being almost a straight horizontal line. When the current exceeds 4,000 amperes, the current transformers saturate and cause the curve to bend rapidly. This saturation protects the relay at high values of current in either direction. When saturation takes place, the ratio of the current transformers not only changes but the phase angle between the primary and secondary currents also changes. The primary current leads the secondary current less and less, with the result that the operating curve bends downward on the right-hand side and upward on the left-hand side. The upward bend improves relay operation on high values of short-circuit current but prevents the relay from operating on high values of charging current. This is indicated on the diagram, where the vector of charging current I_c falls on the closing side of curve 2.

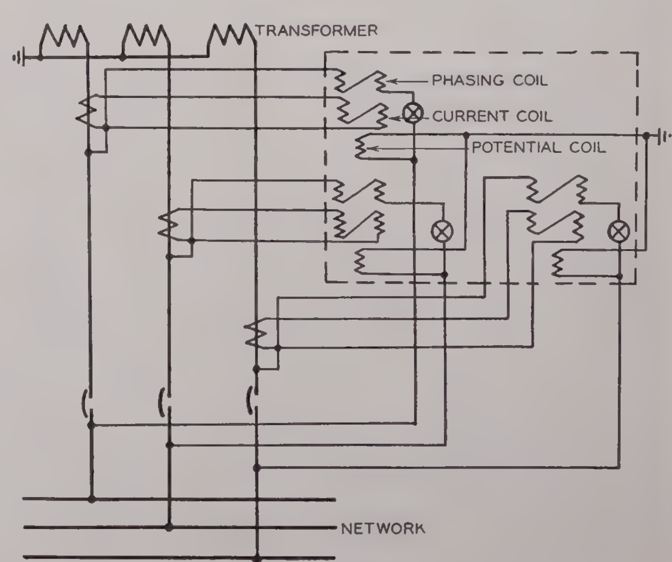
Closing curve 3 is the locus of vectors representing the magnitude and phase relation with respect to the network voltage, of transformer voltages which will produce a balanced torque in the relay. If the vector crosses the closing curve, the protector will be closed; otherwise it will remain open.

Design of Phasing Relay

When the high voltage feeders supplying a network are of different voltage and come from different



Figs. 1 and 2. Schematic diagram of connections for General Electric master relay (above) and for Westinghouse master relay (right)



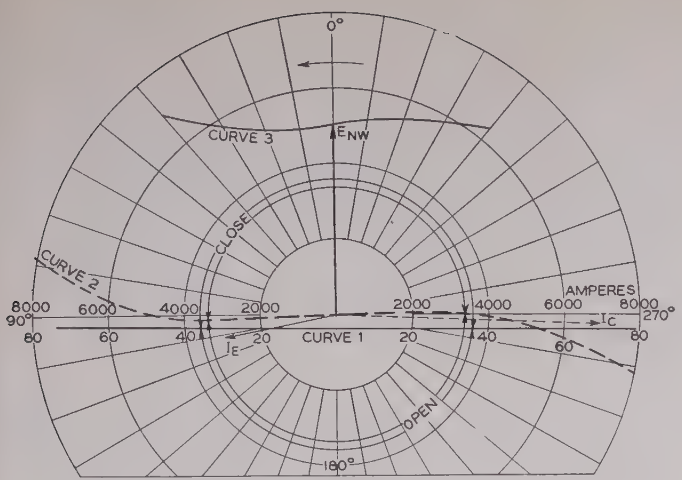


Fig. 3. Characteristics of Westinghouse master relay

For Curve 1 use lower ampere scale; for Curve 2, upper

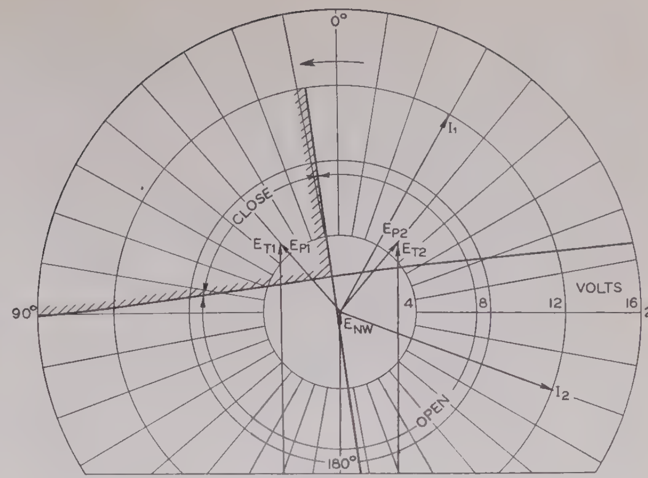


Fig. 4. Closing characteristics of master and phasing relays combined

bus sections of the same generating station, or perhaps from different generating stations, the phase angle between network and transformer voltages with a network protector open may be appreciable. If, during a light load period, the transformer voltage is greater in magnitude than the network voltage but lags it, the phasing voltage may, when the breaker closes, cause power to flow from the network to the feeder. The direction of power flow depends upon the phase angle of the phasing voltage and the impedance angle of the system through which it flows. When such a reversal of power flow occurs, the master relay alternately causes the circuit breaker to open and close, a condition commonly referred to as pumping. Two methods of preventing protectors from pumping are available: one is to add an additional relay called the phasing relay to keep the circuit breaker open when this voltage condition exists; the other is to alter the opening characteristic of the master relay so that it will open the breaker only when the reverse power exceeds a predetermined value. Both methods have been used, each having certain advantages and disadvantages.

The phasing relay is similar to the master relay except that it has a single element and no current coil. The contacts of this relay which controls only the closing of the circuit breaker are in series with the closing contacts of the master relay so that both must be in the closing position before the circuit breaker can close. The constants of the coils in the phasing relay are such that when the phasing voltage is 90 deg. out of phase with the network voltage, maximum torque is produced, the characteristic curve thus being approximately at right angle to the closing curve of the master relay. This relay has an adjustable voltage setting similar to that of the master relay and also an adjustment of the potential circuit constants which permits the curve to be rotated slightly.

Operating Characteristics of Phasing Relay

The closing curve of the phasing relay combined with that of the master relay is shown in Fig. 4. Only those phasing voltages which extend into the upper left-hand quadrant will cause the relays to close the circuit breaker. Thus, the circuit breaker cannot close when a phasing voltage such as E_{P2} exists and which, with little or no load to be supplied, would cause current I_2 to flow and re-open the circuit breaker.

Operating Experience

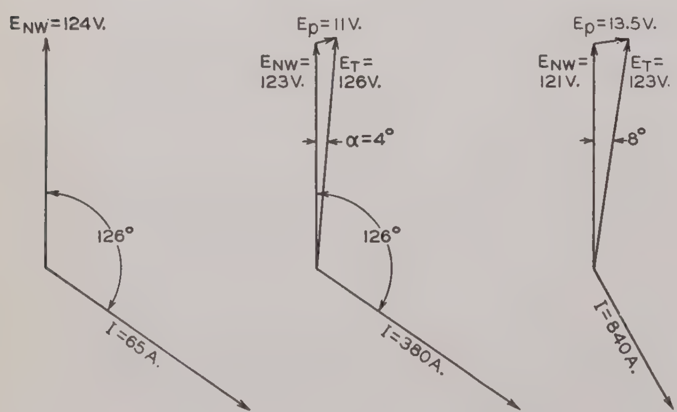
Experience has shown that when phasing relays are necessary to prevent pumping certain protectors may be open at all times except during peak load or may not close at all. When a network is small and the distribution transformers are widely spaced, open protectors are a cause of voltage complaints. If there is an intermittent load on the network occasioned by the starting current of a large motor or electric welding equipment, a voltage dip will occur each time the load comes on, because the transformer capacity is insufficient until the open protectors close. A more serious condition may result if a network is supplied by only two or three feeders, and leading voltage on one feeder keeps the protectors on the others open; for should the first feeder develop a fault, the network will be completely de-energized while the open protectors are closing. The duration of such an interruption of course would be very short; but still it would be sufficient to shut down synchronous machinery or any apparatus controlled by relays operating on loss of voltage. Furthermore, the number of protector operations would be increased. This is an objectionable feature from the standpoint of maintenance and public relations.

Provision for Non-sensitive Relay Settings

As a result of experience and investigation the protectors now being purchased by the New York and Queens Electric Light and Power Company have provision for altering the relay opening characteristic so that the relays may be given reverse current settings up to 20 per cent of the protector rating. The

Westinghouse company provides a spring restraint on their master relay which will give a reverse setting from 0 to 25 amperes. From 25 to 320 amperes the setting is obtained by means of the shunt reactor method. This method consists of connecting a reactor in parallel with each current coil of the relay so that less than 10 per cent of the current in the secondaries of the current transformers flows through the relay. Thus a relay set to trip on 25 amperes in-phase component of reverse current without the reactors, will trip on approximately 250 amperes with the reactors. An additional feature is a set of contacts in each reactor circuit which open on over-current of approximately 150 per cent of the protector rating; for example, when the current on a 1,600-ampere protector exceeds 2,000 amperes, these contacts open and the relay setting drops to that of the spring adjustment. The combination of shunt reactors and cut-outs makes the relay insensitive to all reversals of power obtained under normal conditions, but sensitive to feeder fault conditions.

The General Electric master relay also has a spring restraint which will provide settings between 0 and 25 amperes. To obtain settings above 25 amperes a voltage-restraining element is added. This element, which has two potential circuits, exerts a closing torque upon the bottom disk of the relay. The circuits are energized from the delta side of a Y-delta transformer. The torque exerted by this element is proportional to the area of the delta and as the area of the delta decreases rapidly for single-phase or phase-to-ground faults the restraint or setting decreases likewise. When unbalanced faults occur, one of the watt elements has to provide all or most of



Figs. 5, 6, and 7. Test data of reverse power flow

A back-feed condition caused by a 116-ton punch press driven by a 75-hp. induction motor is shown in Fig. 5 (left). The down stroke of the press drives the motor above synchronous speed and when there is little additional load in the plant, power is supplied to the feeder as indicated; this back-feed caused the protectors to open and the protector relay had to be given a setting of 150 amperes. In Fig. 6 (middle) is shown a back-feed condition due to a phase angle difference between two 4,000-volt feeders supplied by different generating stations. The relays at this location could not be set high enough to carry the back-feed current so a phasing relay was used to prevent pumping. An extreme case, shown in Fig. 7 (right) resulted when two transformers in the same vault were connected to 26.4-kv. feeders from different generating stations, the transformers being lightly loaded during the period of heavy feeder load. The use of a phasing relay to hold the protector open was the only solution

the opening torque, and unless the restraint is reduced in some fashion, abnormally high current is required to cause the relay to open the circuit breaker. To further assist the relay on unbalanced faults, the potential coils of the watt elements are connected phase-to-phase instead of phase-to-ground when voltage restraint is applied. The phase-to-phase voltages are sustained nearer their normal value and so are better able to produce an opening torque than are the phase-to-ground voltages.

Limitations

The objection to the use of non-sensitive settings is that protectors will not open when the station feeder breaker is opened or assuming the network transformers to be connected delta-Y, when a fault occurs between one conductor of the feeder and ground. If the feeder charging current is small or if it is so divided among the transformers connected to the feeder that the amount through each is small, the only disadvantage is the necessity of manually opening the closed protectors. However, if charging current of 3,000 amperes or more were permitted to flow through one transformer, the voltage of the network in the vicinity of the transformer might be raised to a value which would endanger utilization equipment.

The extent to which the network voltage might be raised would depend upon the impedance of the network as well as upon the magnitude and phase angle of the current. If the charging current of a 26.4-kv. feeder, 5 miles or more in length, were supplied by one transformer, the voltage probably would rise 20 per cent, and for certain values of current and impedance might rise 50 per cent. In order that such a condition shall not exist it is the practise in the Borough of Queens to reduce the charging current of each feeder to a safe value by connecting shunt reactors. The lagging current drawn by these reactors added to the charging current gives a resultant current of a magnitude and phase angle which will not cause an objectionable voltage rise.

Experience on this system has been that protectors on 26.4-kv. transformers can be operated with sensitive relays if care is taken in the choice of feeders supplying adjacent transformers. It is intended to limit each protector to one operation a day, and of course to keep all protectors closed which if open would cause the network voltage to drop below the allowable minimum. At the present time only one protector of a total of 150 associated with 26.4-kv. transformers requires a non-sensitive setting.

The use on 26.4-kv. feeders of shunt reactors and sensitive relay settings has resulted in correct relay operation both when feeders are opened at the stations and when phase-to-ground faults occur. However, on lower voltage feeders non-sensitive settings often are required making it necessary to open these protectors manually before a feeder can be cleared for construction work. This means considerable delay and additional expense which should be avoided if possible. This limitation of the present network protection and a desire to simplify the relays have

caused considerable thought to be given to new protective schemes.

Fuses

The network protector fuses which are of the link type and of either copper or alloy, provide back-up protection in case the protector fails to open the circuit in the normal manner when a fault occurs on the feeder side of the protector. They provide protection also to the network transformer when a fault occurs on the network side of the protector which because of its proximity to the transformer, its duration, or both, may result in the transformer becoming overloaded beyond its thermal capacity.

The minimum blowing value of these fuses is approximately three times the full load current of the transformers. This value is less than the value of short-circuit current which will flow into a fault on the transformer side of the protector from an extended network having ample transformer capacity; but this minimum blowing value may not be less than the value of short-circuit current if the transformers are few and widely spaced. However, to use a fuse of lower minimum blowing value would result in unnecessary blowing of fuses with network faults.

Although the blowing of fuses due to network faults has been very infrequent, a solid fault near a transformer which does not clear immediately will cause the fuses to blow. In an area of high load density with transformers a block apart a fault on the network may cause the fuses in three protectors to blow. The disconnecting of this amount of transformer capacity from the network in one locality would result in low voltage.

The use of plain link fuses for back-up protection has certain disadvantages. If the minimum blowing value is low enough to insure opening the circuit for lower values of short-circuit current flowing toward the transformer, they will blow so rapidly on the high values that this blowing may take place before the protector circuit breaker can open. To protect the transformer against overheating when supplying current to network faults, the fuses should have a current-time curve similar to but slightly below the maximum safe current-time curve of the transformer. Because of the pronounced difference in their thermal capacities the curve of the fuse has a steep slope whereas the curve of the transformer has a gradual slope. Thus a fuse which will blow at low values of current only when the transformer has reached its maximum safe temperature, will blow too soon at higher values, and probably unnecessarily. A third disadvantage is the amount of heat generated by the fuses. Elimination of this heat in protectors enclosed in submersible boxes should permit an increase in their current rating.

In place of link fuses there is need for a back-up circuit breaker of small dimensions and low cost which can be given a definite time, overcurrent setting for current flowing from the network, and an inverse time, overcurrent setting for current flowing toward the network. The inverse current-time curve should parallel closely the maximum safe overcurrent-time curve of a distribution transformer.

Molybdenum—

The Metal That Talks

DISCOVERED BY SCHEELE in 1778 in the form of an oxid, molybdenum was first separated as a metal by Hjelm in 1782. Now it is produced commercially by hydrogen reduction of the oxid, pure oxid being obtained from ammonium molybdate. The resulting metallic powder is sintered, forged, and rolled into desired shapes. When pure, molybdenum is soft, white, and ductile.

During the last 35 years a great deal of research work was done in Europe, Japan, and the United States; many characteristics of the metal were developed. It did not come into prominence, however, until the World War when it was used extensively as an alloying element in light armor plate, helmets, and Liberty engines, because of the great increase in strength and toughness imparted by it to steel.

Even in war time, however, its application was limited, due to uncertainty of supply and high cost. In the last few years large deposits of ore have been discovered in the United States; there are deposits of varying richness in many parts of the world, but the largest and richest known are in this country. Commercial deposits are found ranging in richness from 0.5 per cent up to 8 or 10 per cent molybdenum sulphide (MoS_2). After grinding and flotation, the ore is concentrated to about 80 per cent MoS_2; from these concentrates commercial products are made. Rapid lowering of cost by increased production has resulted in a large portion of the world's requirements being supplied from American mines. Hence in times of stress this important element could not be shut off from this country as could some alloying elements used in steel.

It has been said that, excepting carbon, molybdenum is the most potent alloying element added to steel. It can be substituted for tungsten in ratio of 1 for 2. In quantities generally used in steel, molybdenum for the most part goes into solution with the iron, although it forms a double carbid when present in amounts of more than 1 per cent or when considerable quantities of chrome or manganese are present. It also is probable that when cooled through the critical range, a definite compound of molybdenum and iron is formed. Used in amounts as small as 0.1 per cent or 2 lb. to the ton, it has shown marked tendencies in resisting corrosion. In quantities up to 10 per cent it offers a possible substitute for tungsten high speed tool steels.

Thin-walled, high-strength, chromium-molybdenum steel tubing has made modern high speed airplanes possible, and no substitute has been found for highly stressed members in the fuselage. Such tubing combines the unusual advantages of high

From *Research Narratives*, Jan. 15, 1932, published by the Engineering Foundation, 29 West 39th St., New York, N. Y. Based upon information supplied by W. H. Phillips, metallurgist, vice-president, Molybdenum Corporation of America, Pittsburgh, Pa.

strength without complex heat treatment, easy weldability, and no appreciable loss of desirable properties in welded joints; it enables designers to increase strength with no increase in weight.

The pure metal is used extensively in the incandescent and radio bulb industry. According to a booklet, "Rare Metals" (Fansteel Products Company, North Chicago, Illinois): "To say that the air or ether carries the radio broadcast wave is true, but it's a certain metal sealed tightly in tubes which puts the wave on the air, and, then in different tubes, recaptures it to be turned back into music or words. This metal is molybdenum—the metal that talks." Literally thousands of miles of molybdenum wire, drawn through diamond dies, have been used in the radio industry.

But that is not all, for, in the form of salts and oxids, this versatile metal is used in the chemical and dye industries. Thus do we find modern industry, engineering, and research making a place for a material known for a century and a half, but little used until within the last few years.

Engineering Features of Gas Filled Tubes

Introduction of gas or vapor into electron tubes has increased greatly the field of application of these devices. Hot-cathode mercury vapor tubes of this type are especially adapted to rectifier and inverter service. Fundamentals, design features, and operating characteristics of these tubes are given in this article.

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DURING the past few years vacuum tubes have found an ever enlarging field in industrial applications. This has been brought about primarily by vast improvements in the design of the tubes themselves. In addition, the more recent gas filled tube provides the application engineer with a tool even more suited to his needs. Some of the outstanding engineering features of gas filled electron tubes are as follows:

1. The tubes are static devices[1] (For numbered references see bibliography.), the complete functions of which are performed through the movement of electrons and ions.
2. Efficiency in controlling or converting power is high; tube efficiency ranges from 95 to over 99 per cent.
3. Control is flexible and the power required for control is small.
4. Speed of operation as a relay is extremely fast, and in addition the tube may function either cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.
5. Noise and vibration are entirely absent.

Essentially full text of "Engineering Features of Phanotron Tubes" presented at the A.I.E.E. North Eastern District meeting, Providence, R. I., May 4–7, 1932. *Not published in pamphlet form.*

The name "Phanotron" has been applied by the General Electric Company to gas or vapor filled electron tubes, and in that company's practise the name has become associated with the two-element or simple rectifying tube. Tubes of this type in which the starting of the conduction period is controlled electrostatically by the action of one or more grids, have been termed "Thyratron" tubes, the name being coined from the Greek "thyra-," meaning "a door," and "-tron," meaning "a device."

Fundamentals of Theory and Operation

Theory and operation of vacuum and gas filled tubes have been treated previously.[2,3,4] Briefly, the theory in the case of a high-vacuum tube is that electrons can be drawn from the cathode to the anode when the potential of the anode is above that of the cathode. These electrons in passing from cathode to anode form a charged cloud which gives the so-called space-charge voltage drop that depends upon electrode spacing, current drawn, and several other factors; it may vary in magnitude from a few volts to several thousand. In the gas filled tube, electrons are drawn from the cathode as before, but collide with gas molecules in passing to the anode thereby causing ionization which neutralizes the space-charge. Color and appearance of the glow produced is characteristic of the gas and its pressure. The magnitude of the arc drop voltage is practically independent of the current drawn, and for thermionic cathodes within the limits of the tube design is of the order of from 5 to 25 volts. The voltage drop depends upon the available cathode emission, nature and pressure of the gas, and the design and spacing of the tube elements. When the potential of the anode becomes negative with respect to that of the cathode, conduction ceases.

Simple gas filled rectifier tubes consist essentially of two elements: an anode and a cathode, surrounded by an evacuated container into which a partial atmosphere of an inert gas or vapor has been introduced. The cathode may be of the cold, thermionic (hot) or mercury pool type. Any of the

inert gases, such as argon, neon, or helium, mercury vapor, or a combination of these elements may be used. In the more common tubes, the cathode is of the thermionic type, and the vapor pressure is supplied by a small quantity of mercury. During operation nearly all of the current is carried by electrons from the cathode while the positive ions serve mainly to neutralize the space-charge voltage drop.

In the three-element tube a control grid has been added which interposes an electrostatic screen between the anode and cathode as in the high-vacuum tube. When a direct potential is applied to the anode of a high-vacuum tube, its grid gives a continuous, uniform control of the anode current. In the gas filled tube the grid as usually operated controls only the starting of the current and thereafter exerts no appreciable influence upon the current flow. Grid control can be reestablished, however, by removing, reducing to zero, or reversing the polarity of the anode voltage for a period sufficiently long to allow the tube to deionize. If an alternating potential is applied to the anode, the grid has opportunity to regain control during the negative portion of each cycle and to delay the starting of the anode current for as long a period in the positive portion of the subsequent cycle or cycles as desired. It is possible thus to control the average current flowing through the tube.

Control of the average anode current may be obtained by several methods. The critical grid voltage at which conduction takes place when an alternating potential is applied to the anode is somewhat in the form of a sinusoidal wave in phase opposition to the anode voltage. (See Fig. 1.) When a direct potential is used for grid control, the average output varies from zero to half voltage in one step and is then uniform from half to full voltage. If, however, the grid as well as the anode is supplied with an alternating potential of the same frequency, and further, if the phase relations between the grid and anode voltages can be varied, complete and uniform control of the average voltage output may be obtained. In Fig. 1 is shown the effect on the

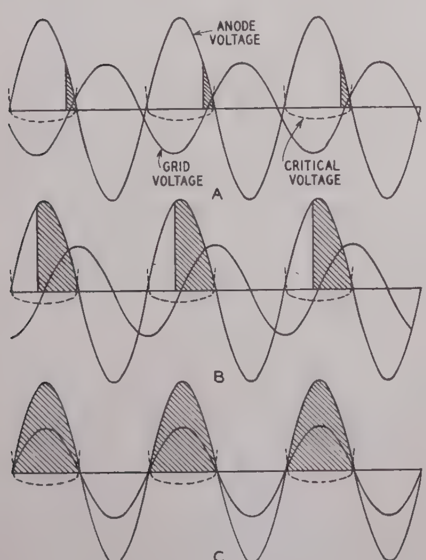
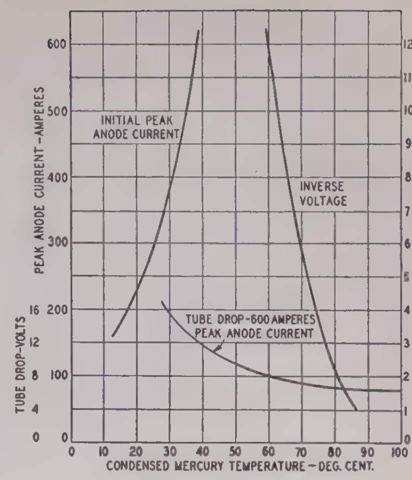


Fig. 1. Control of average output voltage of a gas filled rectifier tube by grid phase-shift method; shaded parts indicate relative average outputs for the three conditions

A—Anode and grid voltages nearly out of phase; B—displaced about 90 deg.; C—in phase

Fig. 2. Tube voltage drop, arc-drop potential, and initial anode current at start of conduction, for a typical two-element mercury-vapor tube



output (shaded portion) as the grid potential is successively advanced from the nearly out-of-phase position (A) to the in-phase position (C). The output may be controlled also by varying the magnitude of the grid potential and by combinations of the d-c. bias, phase, and magnitude methods.

Tube Design and Operating Characteristics

Certain factors of tube design warrant special attention. The type and form of the cathode and anode, the operating pressure of the gas or vapor and the type of grid control require a close degree of coordination in order to insure satisfactory performance.

Cathodes. As already mentioned, three general types of cathodes are in use, namely: the cold, the mercury pool, and the hot or thermionic types. In the cold cathode, electrons are drawn from the cold surface of an electrode through the action of an intense electrostatic field. Cold cathode tubes have a relatively high voltage drop and a comparatively small current carrying capacity.

In the mercury pool tube a cathode spot is established and maintained on the surface of the mercury by auxiliary electrodes. The pool cathode is well known through its use in mercury arc rectifiers[5] and has ability to supply high peak currents. An adequate cooling surface must be provided to condense the mercury evaporated by the cathode spot. Since the tube elements must be shielded from the blast of evaporating mercury and spray, the arc drop voltage usually is higher than that of tubes with equivalent thermionic cathodes.

Hot or thermionic cathodes furnish electrons through the heating of a metal that is an active thermionic emitter or that has been coated with an electron emitting material. The hot cathode used in the majority of gas filled tubes is of the Wehnelt or oxide coated form because of its efficiency, durability, and reliability of operation.

Oxide coated cathodes may be divided into two general types: (1) the filament or directly heated type, and (2) the indirectly heated type. Filament cathodes are used in some of the tubes where rapid heating is essential, and may be shielded. In indirectly heated cathodes, the heating element is

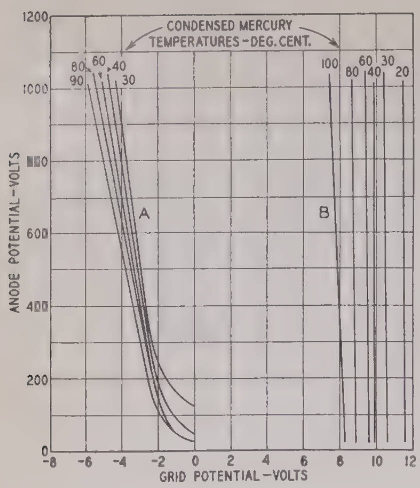


Fig. 3. Voltages at which conduction starts for two typical three-element mercury-vapor tubes with (A) negative control and (B) positive control

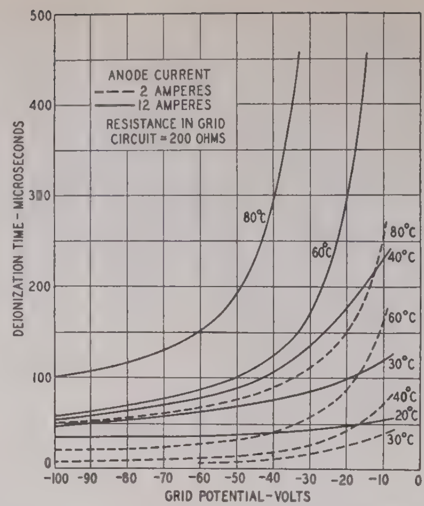


Fig. 4. Deionization time at different condensed mercury temperatures of a three-element mercury-vapor tube designed primarily for inverter purposes

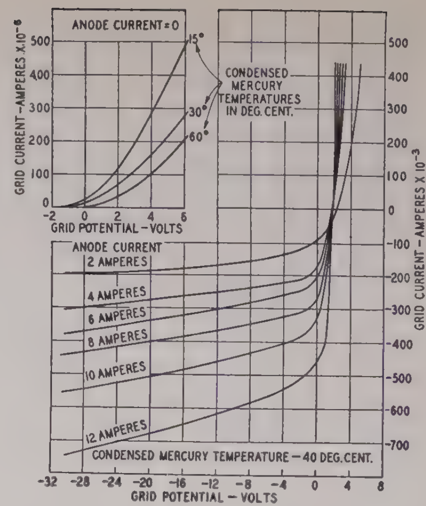


Fig. 5. Grid current vs. grid voltage for several values of anode current for same tube as in Fig. 4

commonly a separate tungsten heater which through radiation or conduction, supplies its energy to the emitting surface.

Heat shielding and concentration of the cathode in small space are made possible in gas filled tubes through ionization of the gas which neutralizes any space-charge and permits electrons to be drawn from crevices and made to emerge from comparatively small holes in the cathode shields. This would be impracticable in high-vacuum tubes. Time required for a cathode to reach operating temperature is a function of the ratio of cathode mass to heating power; consequently, the heating time is a minimum in unshielded cathodes and increases with shielding. In general, the more efficient the cathode, the longer is the heating time. Potential at which the cathode heating power is supplied is held below the ionization potential of the gas (10.4 volts for mercury vapor).

Gas Pressure. Pressure of the gas governs the temperature limits of operation in any gas filled tube. In mercury vapor tubes, the pressure is determined by the temperature of the coldest part of the tube; mercury condenses at this point and a measurement of the temperature gives an indication of the pressure in the tube. With excessive gas pressure, conduction in the reverse direction or arc-back may occur; also under these conditions a three-element tube may lose control. If the pressure is too low, the arc voltage rises above the critical value[2] at which cathode disintegration begins. In addition, low vapor pressure seriously reduces the ability of the tube to start conducting heavy currents; under such conditions, sputtering of the cathode and sometimes arc-back may occur. In general there exists a definite range of pressure for satisfactory operation. For most tubes this range of pressure corresponds to ambient air temperature of from 20 to 50 deg. cent. Temperature rise of the condensing mercury above ambient varies from approximately 15 to 50 deg. cent., depending upon the tube design. These conditions are illustrated in Fig. 2.

Control characteristics of tubes in which an inert fixed gas is used are nearly independent of ambient temperature changes. This characteristic is of particular advantage where large ambient temperature variations are encountered and where constancy of control is desired. Pressure limits are determined by loss of control and reverse current conduction for the upper limit, and by gas "clean-up" for the lower. However, the operating ranges of voltage and current are far less than those of similar mercury vapor tubes.

Control Characteristics. Two classifications of three-element tubes are made with regard to the control characteristics—negative and positive. A negative control tube is one the critical grid voltage of which is negative with respect to the cathode over most of the operating range. Since conduction starts when the grid is negative, very little grid current is drawn before discharge. A positive control tube is one in which the critical grid voltage is positive over most of the operating range. In this type the electrostatic field of the anode is relatively weak at the cathode; consequently, it is necessary to drive the grid positive in order to establish conduction. It may even be necessary first to produce ionization between cathode and grid before anode conduction occurs. Control curves for the two types are shown in Fig. 3.

Ionization and Deionization Time. The time required to establish conduction, sometimes called "ionization time," varies from less than 1 microsec. in two-element tubes and some of the negative control three-element tubes to several microseconds in the positive tubes; it varies with the vapor pressure, tube design, and grid excitation.

Time required to regain control, or the "deionization time," varies with the anode current, vapor pressure, grid excitation, and anode voltage change.[4] Length of the deionization time may vary according to tube design from a few microseconds to approximately 1,000 microsec. This factor is of little importance in ordinary rectifiers or in controlled rectifiers utilizing three-element tubes when operat-

ing at the usual distribution frequencies. Commutation or current transfer from one tube to another is natural and sufficient time exists to regain grid control. In inverters, however, commutation is forced and the available time to regain grid control is short; consequently, tubes having high speed deionization qualities are essential. Deionization time for one type of three-element tube is given in Fig. 4.

Grid current before and after ionization occurs is shown in Fig. 5. These curves illustrate the need of carefully designed grid circuits in order that the grid currents which flow when the gas is ionized do not unbalance the control circuit.

Ratings of Gas Filled Tubes

Certain ratings used in describing gas filled tubes are peculiar to these tubes; some of the more important of these are:

1. Maximum peak inverse voltage.

This is a rating applying to both two- and three-element tubes; it represents the maximum voltage that should be applied between anode and cathode of a tube during operation when the anode is negative with respect to the cathode. Under normal conditions this voltage is simply the crest of the total transformer voltage. These theoretical values may be exceeded several fold under abnormal conditions due to line surges or other disturbances. Determination of the actual peak inverse voltage is necessary in such cases; this may be done conveniently by means of a sphere gap or cathode ray oscillograph. Theoretical peak inverse voltages for several commonly used rectifier circuits are shown in Fig. 6.

2. Maximum peak forward voltage.

This rating applies to three-element tubes only; it represents the maximum positive anode potential that the grid will control when supplied with suitable voltage. In general, the magnitude is the same as that of the maximum peak inverse voltage.

3. Maximum peak anode current.

This is an indication of the available cathode emission, and, for a given life and service, represents the highest instantaneous current a tube will conduct in the normal direction of current flow. The length of time a tube will withstand a given instantaneous current or the frequency with which it will withstand an instantaneous current of given duration depends upon the ability of the tube to dissipate heat.

4. Maximum average anode current.

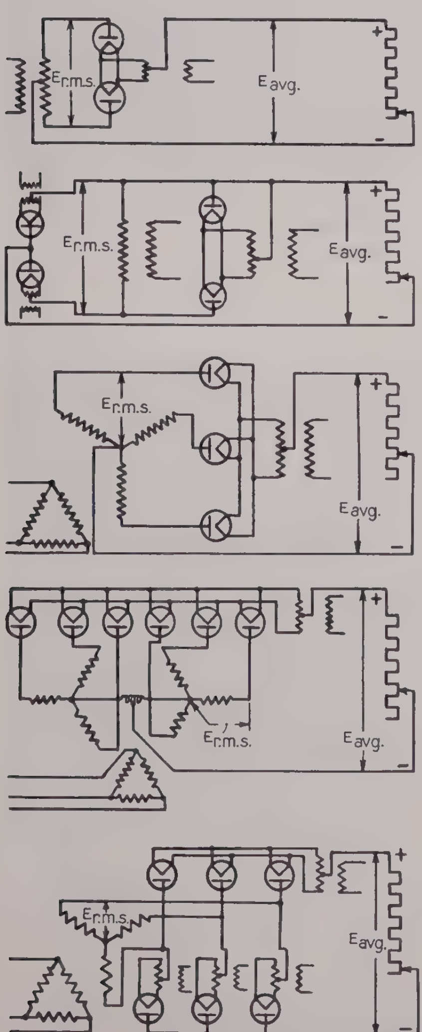
This is a rating based upon tube heating and represents the highest average current that can be carried continuously. Equilibrium temperature of the tube elements is reached quickly for a given load because the elements in general have a small mass; consequently, in addition to the average current rating the integration period must be stated. Losses in the arc vary directly with the average current rather than the value, since the arc drop is practically constant and independent of the current.

5. Maximum surge current.

Under abnormal operating conditions, such as occur when a rectifier is short-circuited, the anode current becomes limited almost entirely by the transformer and line impedance. The short-circuit impedance of power transformers usually is of the order of from 5 to 10 per cent of the rated impedance; consequently, the short-circuit current may reach values of from ten to twenty times normal. In order to indicate the available transient emission of the cathode a "maximum surge current" rating sometimes is given. Individual tubes may fail under short-circuit conditions, but experience indicates that with proper circuit and tube coordination, the majority will stand a great deal of punishment.

6. Maximum peak and maximum average grid currents.

These represent the grid current ratings; usually they have the same integration period as that of the anode current rating.



Bi-phase half-wave, 2 anodes
$E_{avg.} = 0.318\ E_{max.}$
$= 0.450\ E_{r.m.s.}$
$E_{inverse} = 3.14\ E_{avg.}$

Bi-phase full-wave, 4 anodes
$E_{avg.} = 0.636\ E_{max.}$
$= 0.900\ E_{r.m.s.}$
$E_{inverse} = 1.57\ E_{avg.}$

Three-phase half-wave, 3 anodes
$E_{avg.} = 0.827\ E_{max.}$
$= 1.170 E_{r.m.s.}$
$E_{inverse} = 2.09\ E_{avg.}$

Double-Y three-phase half-wave, 6 anodes
$E_{avg.} = 0.827\ E_{max.}$
$= 1.170\ E_{r.m.s.}$
$E_{inverse} = 2.09\ E_{avg.}$

Three-phase full-wave, 6 anodes
$E_{avg.} = 1.65\ E_{max.}$
$= 2.34\ E_{r.m.s.}$
$E_{inverse} = 1.047\ E_{avg.}$

Fig. 6. Typical rectifier circuits and voltage relations for two-element tubes

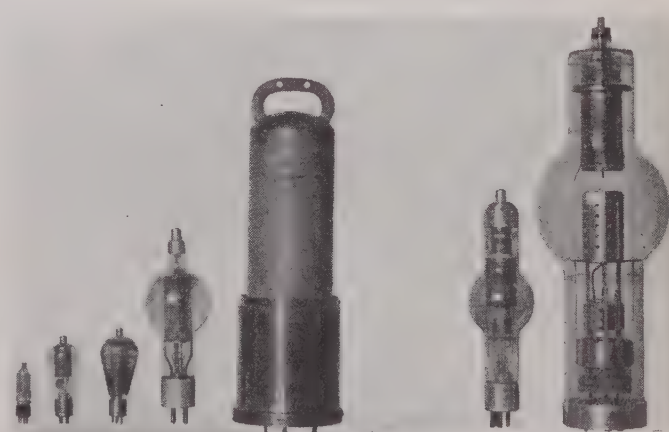


Fig. 7. A group of three-element vapor-filled tubes for control, power rectifier, and inverter purposes

The group of five tubes on the left have maximum peak anode current ratings of from 0.5 ampere for the smallest to 600 amperes for the large metal-clad tube; peak forward and inverse voltage ratings range from 1,000 to 3,500 volts. The two tubes on the right have peak ratings of 15,000 volts and are capable of conducting peak anode currents of 75 and 450 amperes, respectively. Two-element tubes of similar dimensions and ratings also have been developed

Fundamentally, the application of these tubes may be divided into two classes: (1) that of the rectifier in converting alternating current into direct current with or without voltage control; and (2) that of the inverter[6] in changing direct current into alternating current.

Rectifier Application

A typical circuit for a bi-phase, half-wave rectifier with voltage control is shown in Fig. 8. (The term "bi-phase" is a part of a proposed circuit nomenclature for rectifiers.) Current and voltage relations in this circuit are shown in Figs. 9, 10, and 11, for loads approximating resistance, inductance and capacitance operation, respectively. In each case the oscillograph elements have traced the output and anode voltages, and the anode current of one tube.

Oscillogram *A* of Fig. 9 shows voltage and current relations for the rectifier with a resistance load and operating at full output; that is, the grid voltage is in phase with the anode voltage. In oscillogram *B* the grid voltage has been retarded approximately 90 deg. so that anode conduction begins at about the peak of the anode voltage wave. The sudden doubling of the inverse voltage is due to the start of conduction in the opposite tube. With no current flow in either tube, the cathodes assume the potential of the transformer mid point; consequently, the inverse voltage is only half of the transformer voltage. When conduction is established through one tube, the total transformer voltage (less the tube voltage drop) appears across the other.

Effect of introducing an inductance as a filter in the output circuit of the rectifier of Fig. 8 is shown in Fig. 10. In oscillogram *A* the grid voltage is in phase with the anode voltage and the relations correspond to those of simple two-element rectifier tubes. Oscillogram *B* shows the effect of retarding the grid voltage. In the case of a bi-phase rectifier operating with an inductive load, it is possible theoretically to control completely the voltage output with a total grid phase shift of 90 deg. An inductance is essentially a constant current device which stores or releases energy as the voltage applied to it rises or falls. Consequently if the anodes are made conducting by the grids at the peaks of the applied voltage waves or later, anode current will flow in each tube until transferred to the other, or for 180 deg. During half of this time, however, the anode voltage will have reversed its polarity and the net output is zero. The energy relations correspond to those of a circuit with a 90 deg. lagging power factor. The effect of leakage reactance in the transformer upon the commutation or transfer of current from one tube to the other also is shown.

Commutation in a rectifier is a natural process, since the anode voltage of the tube that is ceasing to conduct is falling and that of the incoming tube is rising. During the period when both tubes are conducting, a short-circuit current begins to flow in the reverse direction through the tube that is ceasing to conduct. When the peak of the short-circuit current reaches the value of the previous anode current, conduction ceases.[5]

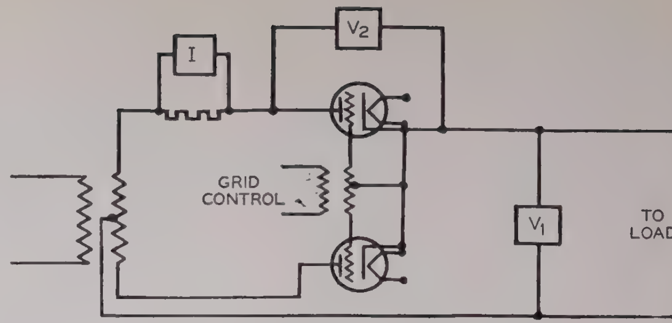


Fig. 8. Simple bi-phase half-wave rectifier circuit using three-element tubes; I, V_1 and V_2 indicate connection of oscillograph elements for determining voltage and current relations shown in Figs. 9, 10, and 11

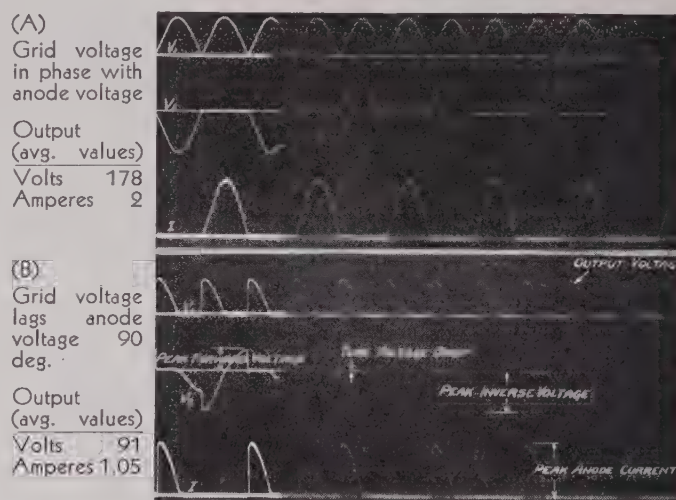


Fig. 9. Voltage and current relations for rectifier of Fig. 8 with resistance load

Portions of the curves have been strengthened for clarity

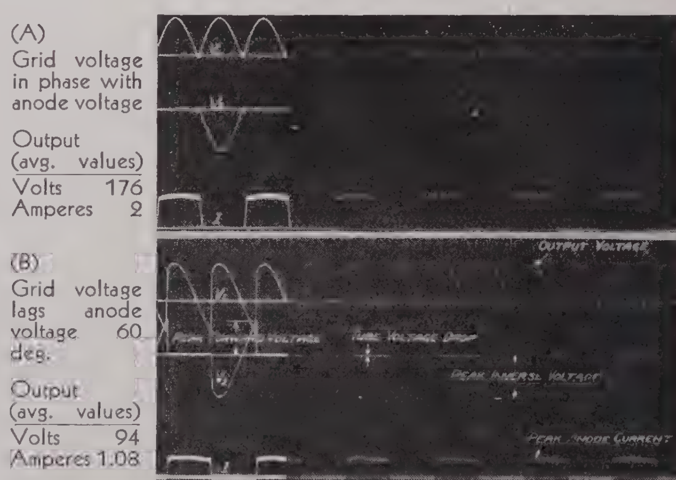
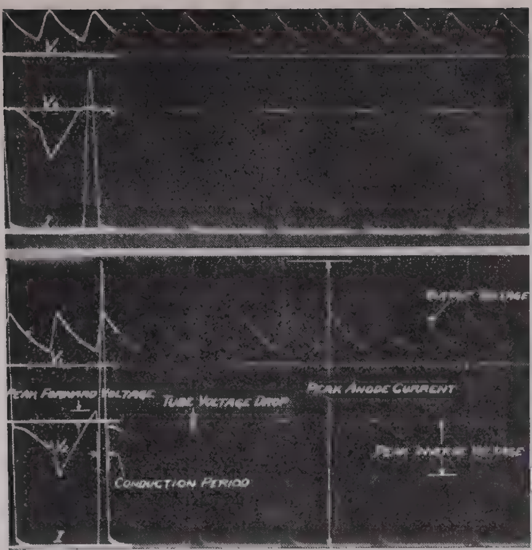


Fig. 10. Voltage and current relations for rectifier of Fig. 8 with series resistance and inductance load

Portions of the curves have been strengthened for clarity

In Fig. 11 operation of the rectifier of Fig. 8 with shunt capacitance is shown for two phase positions of the grid voltage. The peak anode currents that are drawn illustrate quite clearly the low internal



(A)
Grid voltage in phase with anode voltage

Output (avg. values)
Volts 220
Amperes 1.8

(B)
Grid voltage lags anode voltage 70 deg.

Output (avg. values)
Volts 240
Amperes 2

Fig. 11. Voltage and current relations for rectifier of Fig. 8 with resistance load shunted by capacity

Portions of the curves have been strengthened for clarity

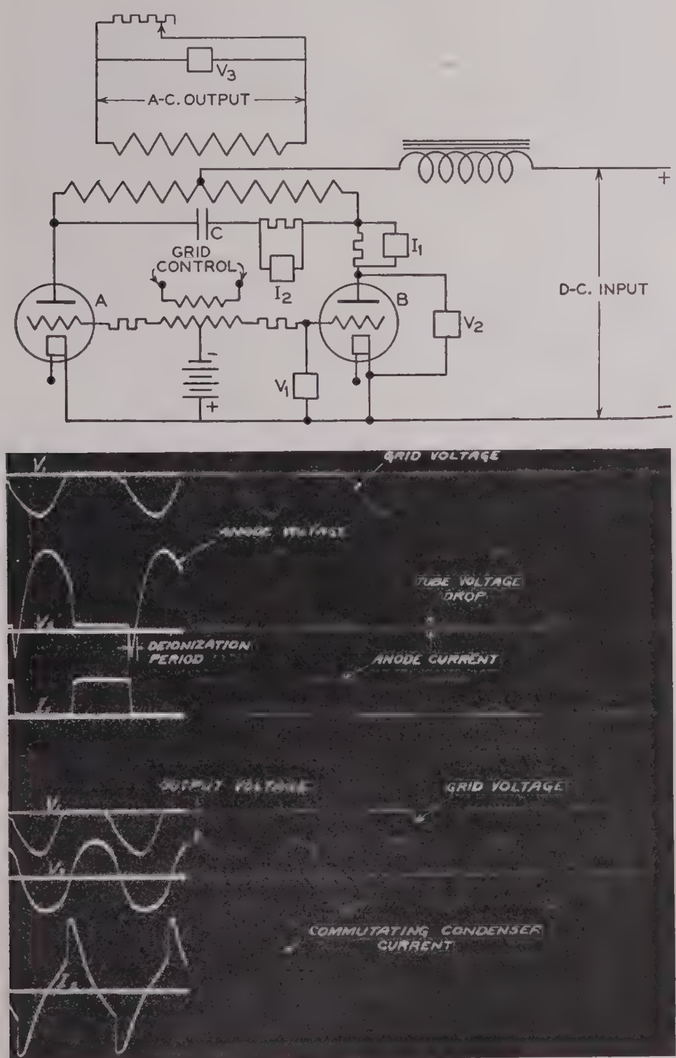


Fig. 12. Single-phase inverter circuit for changing direct to alternating current using three-element tubes, with oscillograms for various voltages and currents

Portions of the curves have been strengthened for clarity

resistance of gas filled tubes. With capacitance operation the maximum peak anode current may be unintentionally exceeded while operating at less than the average current rating.

Inverter Application

When applied to inverter operation the function of the three-element tube is essentially that of a switch for changing the unidirectional flow of direct current to alternate sections of transformer windings. In inverters some form of energy storage is necessary not only to commutate the flow of current from one winding to another, but also to aid in deionizing the tube and so establish grid control.

A simple single-phase inverter circuit is shown in Fig. 12. In operation the grid of tube A, for example, is made sufficiently positive to establish conduction, while the grid of tube B is held sufficiently negative to maintain control. Current then flows from the d-c. source through the inductance and one half of the transformer winding, completing the circuit through tube A. Commutating condenser C becomes charged negatively at tube B and positively at tube A, to a potential the value of which is nearly twice that of the d-c. line. At the end of the cycle the polarity of the grids is reversed and tube B is made conducting. Current that previously had been flowing through tube A is diverted to the condenser, and as conduction ceases the anode of tube A is driven negative, the grid thereby gaining control. Meanwhile, current flow is transferred to tube B and its half of the transformer winding; commutation of the tube currents is then complete. The condenser is charged again but with opposite polarity for repeating the switching operations. On the output side of the transformer the tube voltage waves combine to produce an alternating voltage that by proper circuit constants can be made practically sinusoidal.

Oscillograms of Fig. 12 were taken with the inverter operating at 60 cycles and supplying a resistance load. The relation of the condenser current to the anode current during the commutating period is shown clearly. During the commutation period in order that the grid may gain control, all ions within the tubes in the space between anode and grid must diffuse to the elements before the anode voltage becomes positive. The length of this period is extremely short in comparison to that available in a controlled rectifier. Consequently, the deionization time of the tubes for this service must be short, and in addition, both grid and anode must be designed to withstand severe ion bombardment.

In the present state of development the gas or vapor filled tube has increased manyfold the current carrying capacity of the electron tube. As the field of usefulness increases, even larger tubes and tubes with greater sensitivity of control may well be developed.

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Labor and Engineering Progress

Application of engineering methods, training, and skill to the social, political, and industrial problems of the present day would contribute in a valuable way toward satisfactory stabilization. This is the tenth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
WILLIAM GREEN

President, American Federation of Labor

TO SCIENTIFIC RESEARCH and to the engineers of this country we owe our notable progress in the technical side of industry. Mechanical power is replacing physical power. Workers are controlling machine tools that produce at a rate that would have staggered the giants of the legendary ages. Giant cranes, tractors, steam shovels, double crank presses, conveyers, cash registers, calculating machines, dynamos, and many other devices revolutionized industrial processes. Engineers are largely responsible for marvelous machine tools and for continued experimentation in chemical processes—to put to the service of mankind the last word in science.

The past ten years have brought unusual rapidity in technical progress. This is apparent from comparing the increase in productivity between 1919 and 1929 with that from 1899 to 1919: 54 as against 26 per cent. To state this in another way, this increase in productivity shows up sharply when translated into hours. Work that kept a workman busy 59 hours a week in 1899 was done in 47 hours in 1919; work which was done in a 52 hour week in 1919 was done in 34 hours in 1929. These increases in workers' productivity have brought a steady decrease in the unit costs of production.

In addition to improved tools and processes, the principles of mass production have made available to millions many products which formerly were luxuries within the reach only of those within the higher income brackets. The wage earner with an automobile has access to wider opportunities for work and choice in adjusting the details of living than the wage earner limited by his own traveling capacity. Life and work are now conditioned by control of horsepower. The radio brings him control over wider areas of information and contacts with the personalities and lives of others. Facilities for sanitation and cleanliness give wage earners of today comforts that not even royalty enjoyed two centuries ago.

On the employment side of the ledger, technical progress has brought exceedingly difficult problems to workers and industry. Our term *technological unemployment* expresses an experience that often has made science seem the enemy of wage earners. But this is because science has been used without taking into consideration the fact that wage earners have an equity in their jobs. How to make quantities has been learned, but not how to get them to the people who can use them, or how to distribute equitably the returns from joint products. Present attempts direct these modern currents through the old channels developed in the days of hand production.

Wage earners make a very important investment in industry. They put in the time and labor necessary to turn out the products of the industry; they put in their creative capacity, their intelligence, their work lives. The time has been reached when securities for these non-material investments must be given consideration commensurate with that for capital investments. Merely speeding up the industrial machine is not an unmixed good unless engineers realize that these changes profoundly affect human lives, and plan to make the influence constructive.

When undertakings are going to affect one or more groups, the only way to make sure that all those having legitimate interests are safeguarded is to provide for collective consideration and counsel. This is in accord with the engineering practise of finding and applying facts. This field of facts of human progress affords the ultimate tests of the value of engineering progress. Failure to consider the consequences of policies and changes upon interrelated interests results in perplexing problems that impede progress and precipitate strife.

World-wide economic distress has resulted from failure to recognize interdependence of national interest. Within our country is found failure to balance interests and progress. Custom has established certain priorities for material interests that have worked for unequal distribution of wealth and income

and absence of security for many. Wage earners belong to the groups denied priorities in security.

It has been pointed out that, because all interests are interrelated, we must work out principles of balance; increasing output against capacity to buy; increasing productivity against increasing leisure, technical progress against the available supply of labor, output against the incomes of buyers, volume of business against available credit, etc. Sustained business prosperity can be attained only through an understanding and application of the principles of balance. The welfare of mankind can be advanced safely in this complicated age only when the principles of balance between forces which work for progress and retrogression are understood.

To define its status and well-being, Labor has outlined the following Labor program:

1. Organization of all functional groups to advance their group interests, and collective conferences and agreements to promote progress for all, in which Labor shall participate.
2. Reduction of weekly work hours as productivity increases.
3. Wage increases to raise consumer credit as output increases.
4. Partnership of labor in the production undertaking, carrying job, and income security.

Application of these principles would give Labor and all other groups a fair chance to advance their interests in individual establishments, but this is not enough. The industries of a nation are dependent upon each group for prosperity or depression. Therefore, there must be nation-wide planning by industries and collective discussion and agreement for the nation, together with consideration of the world market.

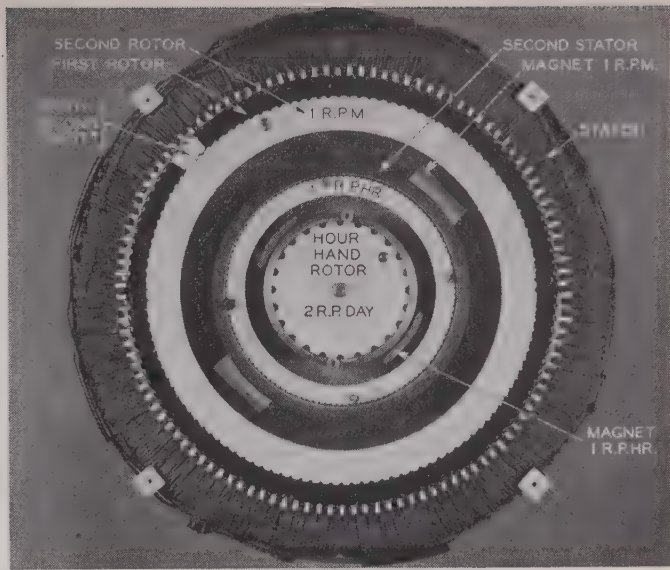
To these larger problems which include the intangible as well as the technical forces with which engineers are familiar, the engineers of the country can make valuable contributions. It is hoped that engineers will feel a responsibility for carrying their methods of work into the larger field.

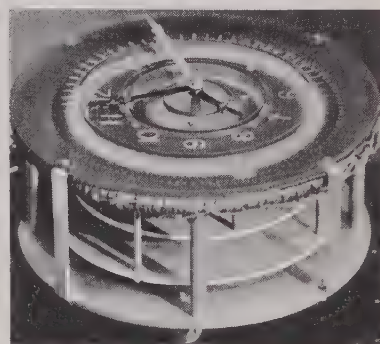
Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

Slow Motion Motor Will Run Indefinitely

WHILE one group of scientists has been perfecting electrical machinery that will run at higher and still higher speeds, another group has been going to the other extreme by perfecting a timing motor that will revolve only twice a day. By following the same principles the speed could be slowed down to one revolution per year or even less.

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*





Slow motion synchronous motor (above) as built for the experimental clock shown in the smaller view. There are only four moving parts, one for each hand and one for the split-second "spot." The clock is 10 in. in diameter and 6 in. high

Theoretically there is no limit to the slowness that could be achieved, according to L. W. Chubb and T. R. Watts research engineers of the Westinghouse Electric and Manufacturing Company.

While the idea is still in the experimental stages and is not commercially available, the fact that it is practical and workable has been demonstrated in a clock of unique design. One feature of the clock is that it has only four moving parts, each of which is necessary to operate one of the hands. The fastest of these revolves only 60 times per minute. If the four points of wear were to be sealed in oil cups and jewels used for bearings as in good watches, the clock should run indefinitely without attention; of course such performance would require that the electric current never be interrupted.

In the accompanying illustrations are shown a view of an experimental model of the clock, together with a plan view of the slow motion motor. Just below the outer rim of the clock face is the stator of the motor having 118 iron teeth around its inside edge and wound so as to provide a revolving magnetic field. Inside this ring is the rotor around the outer edge of which are 120 iron teeth. With different numbers of teeth on the two parts, only two teeth are synchronized at any one time and there is a vernier effect around the rest of the circle. This causes the motor to move only the distance of two teeth for each revolution of the magnetic field of the stator. Thus on a 60-cycle system with the stator field revolving at the rate of 3,600 times per minute,

the rotor revolves only 60 times per minute, the speed required for a split-second hand.

Around the inner edge of the rotor ring are 122 teeth; inside this is a second rotating iron ring of still smaller diameter with 120 teeth around its outer edge. In this second reduction of speed the first rotor becomes the stator for the second, but while the first is running forward 60 revolutions, the second is running only one, so that its net progress forward is one revolution per minute. This is the speed desired for the second hand.

Attached to the second hand rotor is a permanent horseshoe magnet which creates a new rotating field in 118 iron teeth driving still another ring with 120 teeth at the rate of one revolution per hour. This runs the minute hand. Attached to the minute hand rotor is a second permanent magnet creating a rotating field in 22 teeth and driving a 24-tooth rotor one revolution every 12 hours for the hour hand. The entire operation may be explained by saying that each rotor travels only two teeth for each revolution of its magnetic field. Obviously by changing the number of teeth, any desired speed may be obtained.

Magnet Steels and Permanent Magnets

A new relationship connecting the open-circuit remanence of a permanent magnet with the factors which determine its value has been found. This relationship, shown by Fig. 2 of the following article, appears to be general and valid for all kinds of magnet steel. Also, criterions of magnetic quality are presented, including a nomogram chart for permanent magnet design.

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GENERAL STUDIES of the magnetic properties of magnet steels and permanent magnets embrace a number of related problems, prominent among them being the determination of the relation between the open circuit remanence of a permanent magnet and the various factors which determine its value. These factors include the magnetic characteristics or properties of the steel, as displayed by its hysteresis loop, and the shape and dimensions of the magnet. Of interest to the manufacturer of magnet steel are the questions of how chemical composition, and melting and rolling practise affect the magnetic and mechanical properties of the steel. The manufacturer of magnets is interested in the effect of the necessary manufacturing operations, such as heating for hot forming and annealing to increase machinability upon the flux obtainable in the finished magnet, in the tendency of the steel to warp or crack upon quenching, and in the proper hardening treatment to use.

Other special subjects may be listed, including the manner in which various influences may affect the state of magnetization of a magnet, the correlation of the microstructure and mechanical properties of a magnet steel with its magnetic properties, the determination of a suitable criterion of magnetic quality, the development of accurate and convenient testing equipment, and various other matters of greater or less importance. It is the purpose of this article to present data relating to some of the above topics which have been collected during the course of several years connection with the manufacturer of permanent magnets, both in the laboratory and in the shop.

The following symbols and notation are used in the paper. All values of B are intrinsic or ferric induction.

B_{max}	= The value of magnetic induction corresponding to the tip of a given hysteresis loop
H_{max}	= the value of magnetizing force corresponding to B_{max}
B_s	= the saturation value of flux density corresponding to an infinite magnetizing force
B_r	= residual induction, the magnetic induction in a closed ring or infinitely long straight bar after the value of H has been reduced from H_{max} to 0
H_c	= coercive force, the value of H required to reduce B from B_r to 0 in a ring or an infinitely long bar
B_{rem}	= remanence, the magnetic induction at the magnetic equator of a permanent magnet with no external magnetizing or demagnetizing force. Values of B_{rem} in this paper are without pole pieces on the magnets
L	= the actual developed length of a magnet
A	= the area of cross-section of a magnet
D	= the equivalent diameter of a magnet = $2\sqrt{A/\pi}$
L/D	= the dimension ratio of a permanent magnet
T	= hardening temperature, absolute scale
T_o	= optimum hardening temperature, absolute scale
$(BH)_{max}$	= the maximum value of the product of the coordinates of the demagnetization curve for a given steel. The demagnetization curve is the portion of the hysteresis loop between B_r and H_c

Factors Determining Remanence of a Permanent Magnet

It was desired to determine the relationship between the remanence of a permanent magnet and the various factors which determine its value. As it was supposed that shape was one of these factors, and in order to control its influence as a variable, all tests were made upon straight bars. This form of test specimen possessed the advantages of being easily

Based upon "Magnet Steels and Permanent Magnets—Relationships Among Their Magnetic Properties" (No. 32-24) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

obtainable, easily duplicated, and well adapted to the measurement of magnetic properties in a permeameter as well as to remanence measurements with a search coil.

Accordingly, a large number of straight bars was collected during the course of several laboratory investigations. Each of the bars was 12 in. in length. In the lot were bars of $^1/_8 \times 1^1/_2$ in., $^1/_4 \times {}^1/_4$ in., $^3/_{16} \times {}^3/_4$ in., $^1/_4 \times 1^1/_4$ in., $^3/_4 \times {}^5/_8$ in. and $^3/_8 \times {}^1/_2$ in. cross-sections. All available types of steel were represented, including a 0.9 per cent chrome steel, a 3.5 per cent chrome steel, a 0.85 per cent manganese steel, a 5 per cent tungsten steel, and 20 per cent, 25 per cent, and 36 per cent cobalt steels. The range in coercive force was from 40 to 260 oersteds accompanied by values of residual induction varying from 6,000 to 11,000 gausses.

Experimental Procedure

The test bars were hardened in the manner appropriate to each kind of steel, except that some bars purposely were quenched from a high temperature in order to secure low values of B_r. After hardening, the demagnetization curve for each bar was determined by means of permeameter measurements, using the Babbitt permeameter and a Grassot flux meter with lamp and scale. The control circuit of this permeameter is the conventional circuit for a ring test. All magnetic data are comparable since all of the test specimens were measured by the same instrument. (See "An Improved Permeameter for Testing Magnet Steel," by B. J. Babbitt, *Opt. Soc. Amer. Jl.*, v. 17, 1928, p. 47.)

Following the permeameter measurements each bar was magnetized as a straight bar magnet in an air core solenoid. Field strengths of over 1,000 oersteds were applied to each bar. Upon removal from the solenoid the flux density at the middle of the bar was measured by means of a search coil and the Grassot flux meter with lamp and scale. This is the quantity referred to as B_{rem} in this article.

After the measurements at 12-in. lengths were completed, each bar was cut by removing 1 in. of material at each end, to successive lengths of 10, 8, 6, 4, and 2 in., except that in the case of some of the bars of larger cross-section the lengths of 10, 6, and 2 in. were omitted. Remanence measurements were made at each of the above lengths. The bars were remagnetized for each new measurement of B_{rem}.

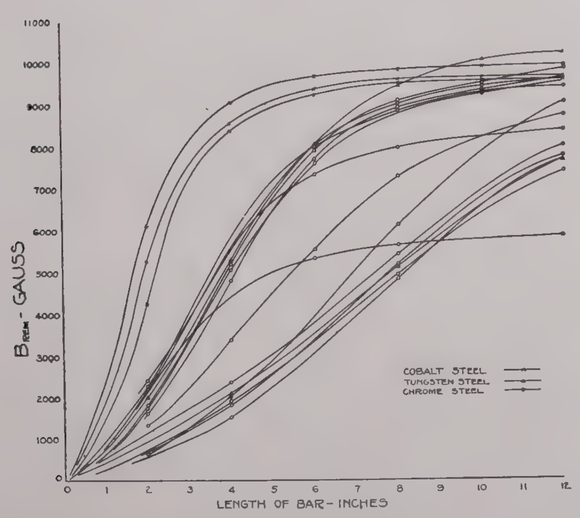

Fig. 1. Remanence versus length for straight bar magnets of different cross-sections and materials

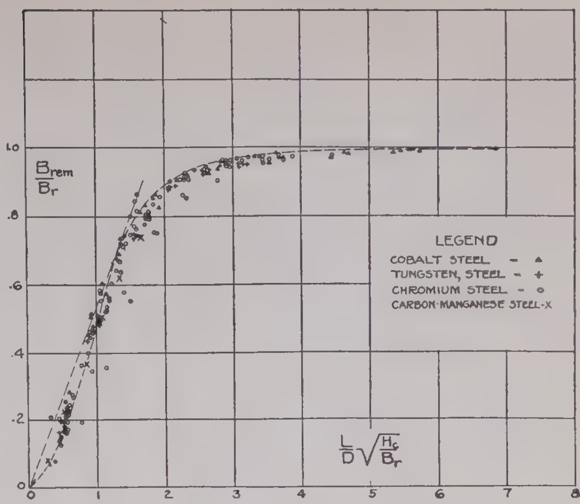

Fig. 2. Correlation between the combinations of variables indicated, for bars of any kind of material, magnetic properties, length, and cross-section. Same data as in Fig. 1

The foregoing experiments made available for analysis a wide range of values of the associated variables B_{rem}, B_r, H_c, L, and A.

Analysis of Data

For a number of the specimens the values of remanence versus length are plotted in Fig. 1 to show the range of values existing in different bar magnets of the same length, but of different cross-sections and materials when fully magnetized. The differences in B_{rem} for a particular length of bar are due to the differences in B_r, H_c, and cross-section of the various specimens. The chief characteristics that the several curves of Fig. 1 have in common are a general resemblance in shape to a normal induction curve, and an asymptotic approach to limiting values of B_{rem} as the lengths increase.

In Fig. 2 is shown the result of plotting $\frac{B_{rem}}{B_r}$ against $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ for the same set of bars. The combination of variables $\frac{L}{D}\sqrt{H_c}$ was arrived at by a purely cut-and-try process, but it was later suggested to the writer that it would be preferable to use $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$. In either case, a surprisingly good correlation is obtained.

As shown in Fig. 2, a line drawn through the origin and tangent to the dotted curve of that figure has its point of tangency at values of $\frac{B_{rem}}{B_r}$ and $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ of approximately 0.65 and 1.25, respectively. It will

be shown later that this is the point of maximum efficiency; *i. e.*, the point at which are obtained the highest values of B_{rem} or external magnetic energy per unit volume of steel. It follows that magnets should be so designed that $\frac{L}{D}\sqrt{\frac{H_c}{B_r}} = 1.25$ and $\frac{B_{rem}}{Br} = 0.65$. The nomogram of Fig. 3 was laid out on this basis. The use of this chart to design a magnet of maximum efficiency is illustrated by the dotted lines of the figure. In the case shown, a total flux in the magnet of 3,000 maxwells is desired, and a steel with a B_r of 10,000 gausses and a coercive force of 54 oersteds is assumed. The correct values of A and L are found to be 0.461 sq. cm. and 13 cm., respectively, and the dimension ratio is 17. If the nomogram is applied to the design of other than straight bar magnets, the length given by the chart will be too great, depending upon how close the poles of the magnet come to each other.

Criterions of Magnetic Quality of Permanent Magnet Steels

A number of quantities determinable by magnetic measurement has been proposed at various times by different investigators for use as criterions of the magnetic quality of magnet steels. Among these may be listed $(BH)_{max}$, B_rH_c, B_r/B_{max}, $(B_rH_c)/(B_{max})$ and B_r/H_c. The first of these criterions is discussed in "Permanent Magnets in Theory and Practise," S. Evershed. *Instn. Elec. Eng. Jl.*, v. 58, 1920, p. 780, and v. 63, p. 725, 1925; the second in "Ein neues Material für Permanente Magnete," E. Gumlich, *Elektrotech. Zeitsch.*, v. 44, 1923, p. 147; and the last criterion is discussed in the following two articles by J. A. Mathews: "Magnetic Habits of Alloy Steels," *Am. Soc. Testing Matl. Proc.*, V. 14, 1914, p. 50; and "Retained Austenite—a Contribution to the Metallurgy of Magnetism," *Am. Soc. for Steel Treating Trans.*, Nov. 1925, p. 565.

The quantity $(BH)_{max}$ was proposed by S. Evershed, and his theoretical justification for it is convincing, but an experimental verification seemed desirable. Data from the bars shown in Fig. 3, and others, were used for this purpose. These data are shown on Fig. 4. For each bar there is plotted, from left to right, its demagnetization curve as determined in the permeameter, the derived curve of BH versus B, and the curve of B_{rem} in terms of length, all plotted to the same scale of B. Fig. 4 shows that if tangents to the curves of B_{rem} versus length are drawn through the origin, the point of tangency in each case indicates the value of B_{rem} and length for which the value of $B_{rem}/length$, or $B_{rem}/volume$, is a maximum. It is clearly shown that in each case these values of B_{rem} coincide with the values of B for which the product (BH) is a maximum, thus indicating that the $(BH)_{max}$ point is the point of maximum efficiency for the magnet, while a comparison of the curves shows that the value of $(BH)_{max}$ is a measure of the efficiency or quality of the steel. It is believed therefore that the quantity

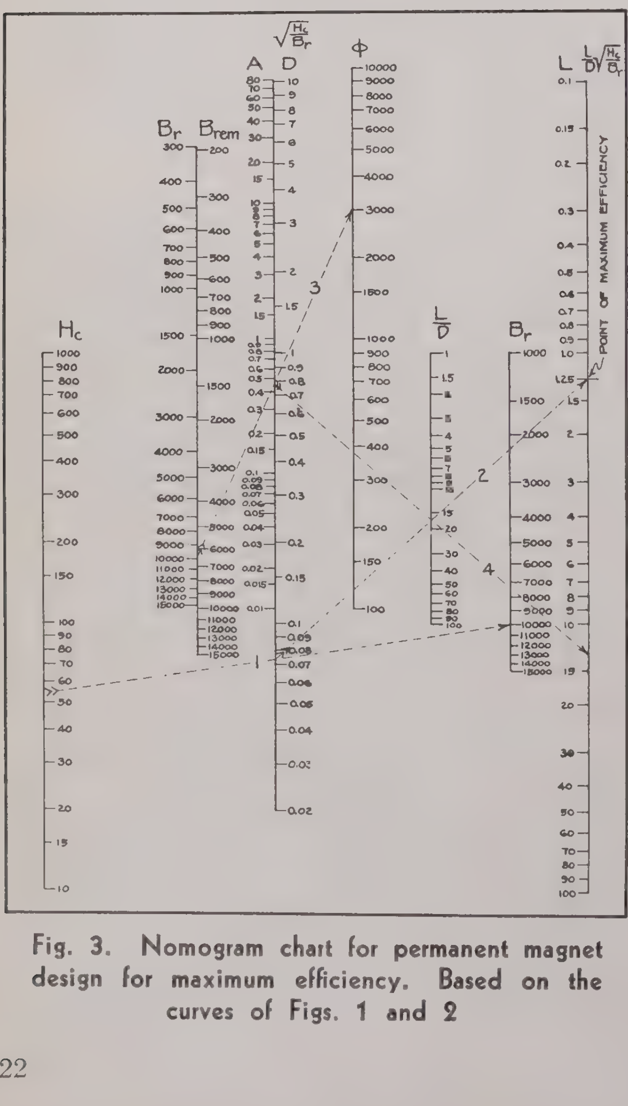

Fig. 3. Nomogram chart for permanent magnet design for maximum efficiency. Based on the curves of Figs. 1 and 2

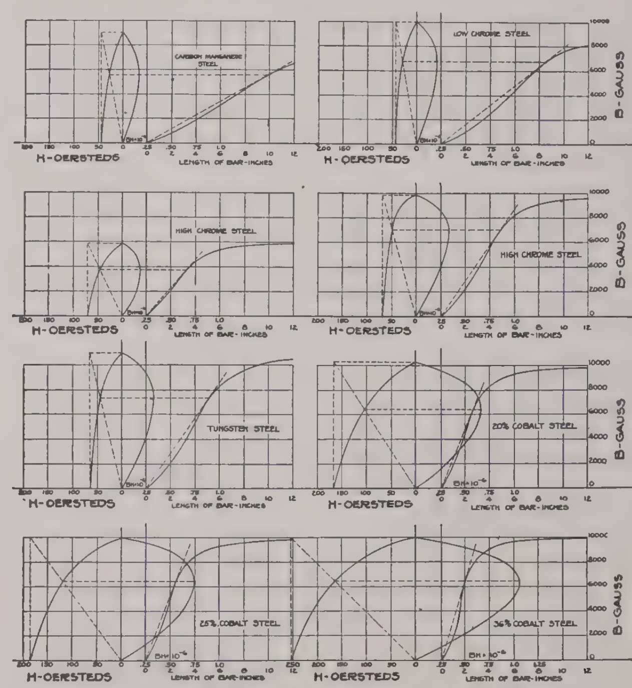

Fig. 4. Experimental verification of validity of Evershed's criterion for magnetic quality of permanent magnet steels

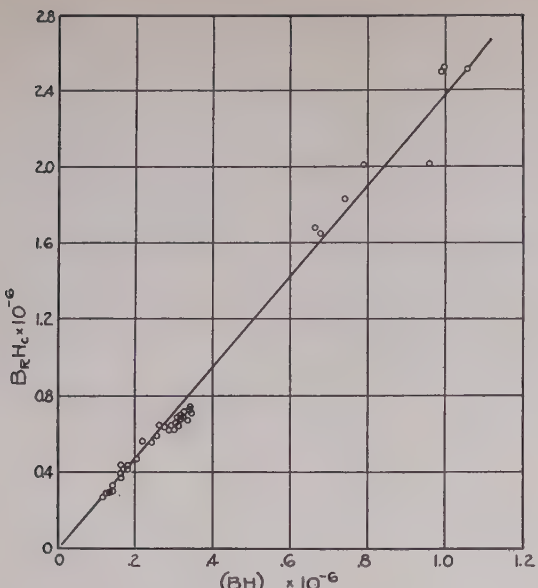

Fig. 5. Relation between the quantity B_rH_c and Evershed's criterion $(BH)_{max}$

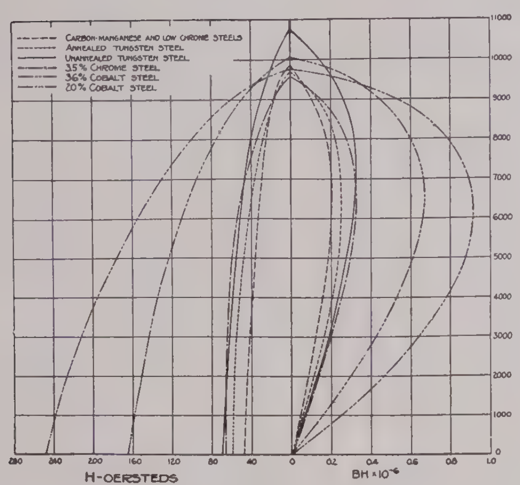

Fig. 6. Typical demagnetization curves and curves of BH versus B for various kinds of magnet steel

$(BH)_{max}$ furnishes a wholly reliable measure of the quality of a permanent magnet steel. It can be used to select from a choice of compositions or heat treatments the one which is the best in terms of magnetic energy in the air-gap of the magnet per unit volume of steel in the magnet. The optimum hardening temperature, previously referred to, is defined as the hardening temperature at which is obtained the maximum value of $(BH)_{max}$ for a given type of steel.

The product B_rH_c is shown by Fig. 5 to bear an approximately linear relationship to $(BH)_{max}$, and as B_rH_c can be determined with less effort, it is preferable for routine use as a criterion. The other quantities mentioned are all open to serious objection as being in some cases either meaningless or actually misleading. A number of typical demagnetization curves and the derived curves of BH plotted against B is given in Fig. 6.

Supervisory Control for A-C. Electrified Railroads

IN ITS ELECTRIFICATION in and around Philadelphia, the Pennsylvania Railroad has made use of two installations of supervisory control for the remote operation of high voltage a-c. step-down substations. In a current A.I.E.E. paper (see footnote) C. P. West (M'28) Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and H. C. Griffith, Pennsylvania Railroad Company, Philadelphia, Pa., describe some of the features of the installation and relate in detail how some of the difficulties encountered were solved.

When the electrification was put into service, interference with the supervisory equipment was experienced from induced voltage in the control wires when the trolley circuits were fed from one end. This interference was evidenced by chattering of the relays, and flashing over, and sometimes destruction, of the protector tubes; in case of trolley fault, fuses were blown.

After attempting by several other means, to obviate the disturbing effects of the induced voltages, one of the installations was rebuilt using a new method of control known as the *visicode* system, brought out by the Westinghouse company. This scheme utilizes only two line wires and operates by means of d-c. unidirectional impulses; it is ideally suited to the limiting of effects of low frequency induction. A special reactor connected in each end of the control system line is said to be the key to the successful application of this circuit. With this arrangement a low induced current can flow continuously in the two supervisory, line wires without flashing the protector tubes or interfering with operation. A high quality of operation has been obtained since the rebuilding of this installation. In the second installation, the synchronous visual set originally installed has a rather short line circuit and is not so closely located to contact line circuits; this original equipment continues to give good operation.

When these types of supervisory control equipment have been adjusted properly, they are said to operate with very little maintenance; where the equipment is in a clean neighborhood and is operating satisfactorily, inspection periods can be extended to as long as four months. In conclusion the authors state that, "The results obtained by the Pennsylvania Railroad have shown that when the substations are located where control points are so distant that the installation of direct control cables is not economical, control can be adequately obtained by the use of proper supervisory equipment.....It may be safely stated that supervisory control is destined to play an increasingly important part in future railroad electrification."

Abstracted from "Supervisory Control for A-C. Electrified Railroads" (**No. 31-93**) by C. P. West and H. C. Griffith, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Standard Decrement Curves

Standard decrement curves in use for a number of years in the calculation of power system voltages and currents under fault conditions now have been revised and are presented herewith. Their use enables the determination of the magnitudes of voltages and currents for various intervals of time subsequent to the occurrence of a fault.

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APPLICATION of circuit breakers and relays on power systems frequently requires a determination of the magnitude of voltages and currents under fault conditions for various intervals of time measured from the instant of the application of the fault. The decay of fault current from initial to sustained values commonly is determined by means of decrement curves. A standard set of decrement curves was published for the first time in 1918 (see reference 1 in bibliography). These were revised in 1923, and published in the N.E.L.A. Relay Handbook (1926) and in various manufacturers' publications.

In the past eight years there has been considerable progress in the analysis of transients in synchronous machines. Furthermore, the method of symmetrical components has come into general use for the calculation of unbalanced faults. These developments in theory, together with the increased knowledge of machine constants, have made desirable a new set of decrement curves. Such a set now has been prepared and is given in Figs. 1 and 2. These curves have been approved by the National Electrical Manufacturers Association.

Refinements Secured

A single decrement for the a-c. component of fault current was assumed for the 1923 decrement curves. The new curves take into consideration the fact that the a-c. component is made up of two exponential terms and the fact that the transient time constant varies with system reactance. The method of using the curves includes a means to give more accurate results in case the time constants of machines differ appreciably from the assumed average figures upon which the curves are based.

Three separate groups of curves, one for each type of fault, namely, three phase, line-to-line, and line-to-ground, were included in the 1923 curves. The new decrement curves include only a single set which, however, is applicable to the same three types of faults. This is feasible because the new curves are based upon the method of symmetrical components. The old curves assume equal initial values of line-to-line and three phase currents whereas the present curves are plotted for the more usual ratio of 0.866. The old curves for line-to-ground faults were re-

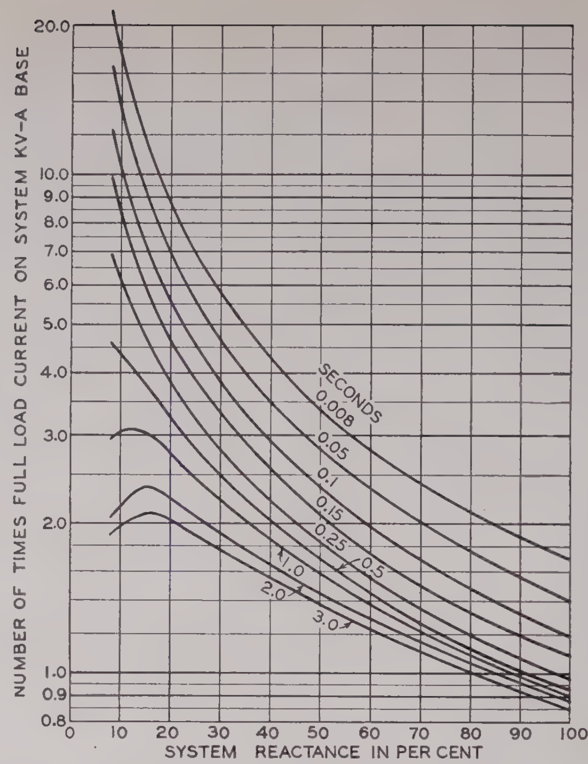


Fig. 1. Standard short-circuit decrement curves for synchronous machines

System reactance must be based on system kva. and not on the particular kva. chosen as a base for calculations. System kva. is connected synchronous capacity in kva.

These curves are based on $T'_{do} = 5$ sec. For other values multiply actual times by $\frac{5}{T'_{do}}$ to get equivalent times to use in curves.

For three-phase short circuit—
Reactance—Use system reactance to the point of fault
Times full load (normal) scale—use scale reading

For line-to-line short circuit—
Reactance—Use two times system reactance for three-phase fault
Times full-load (normal) scale—Multiply scale reading by $\sqrt{3}$

For line-to-ground short circuit—
Reactance—Use $(2x_1 + x_0)$ or
$$\frac{3 \times \text{(initial three-phase short-circuit current)}}{\text{(initial line-to-ground short-circuit current)}} \times$$
system reactance for three-phase fault
Times full-load (normal) scale—Multiply scale reading by 3

Based upon "Standard Decrement Curves" (No. 32-53) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

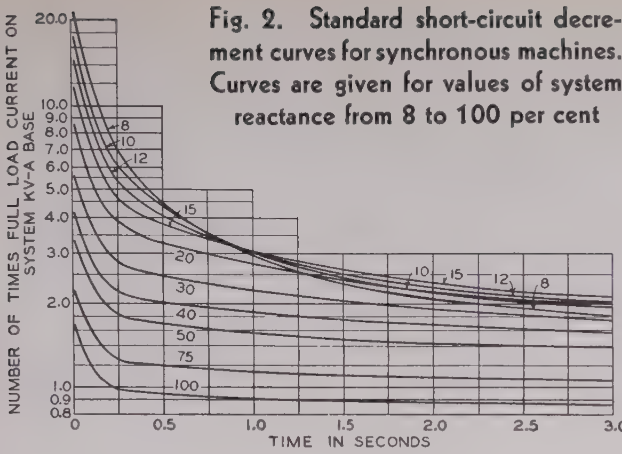


Fig. 2. Standard short-circuit decrement curves for synchronous machines. Curves are given for values of system reactance from 8 to 100 per cent

stricted to the particular case of a fault on the terminals of one or more generators all the neutrals of which were solidly grounded; the new curves were not restricted in this respect.

No distinction was made between machines with and without damper windings in the 1923 curves, while the present set has been designed to apply particularly to salient pole machines with amortisseurs, and to turbine-alternators. They therefore give inaccurate results for the first 0.2 sec. for salient pole machines without damper windings and are supplemented by a method of calculation which gives the initial value of short-circuit current accurately for these machines.

Basic Assumptions

The basic assumptions from which the new curves have been derived are as follows:

1. Immediately preceding the short circuit the generators are operating at rated voltage and kilovoltamperes at 80 per cent power factor.
2. No automatic voltage regulator is used.
3. The actual system subjected to fault may be represented by a single equivalent generator of the same total rating and an external reactance.
4. The load is located at the machine terminals; the machine reactance is taken as 15 per cent unless the total reactance is less than 15 per cent, in which event all the reactance is assumed to be in the machine.
5. The short circuit occurs on an unloaded feeder.
6. The short circuit occurs at the point of the voltage wave which corresponds to maximum possible instantaneous current.
7. All resistance in the circuit including the resistance of the fault is neglected.
8. All the machine e.m.f.'s are in phase.
9. The machine reactances and time constants are those of representative modern machines. Of particular importance is the relation between transient and subtransient reactance of machines as shown in Fig. 3.

Application of Standard Decrement Curves

The decrement curves of Figs. 1 and 2 give the r.m.s. total current expressed in terms of "times normal current" with total connected synchronous capacity in kilovoltamperes as a base. The same data are given in both figures, system reactance in per cent being used for the abscissas of Fig. 1, while elapsed time in seconds is used as the abscissas of Fig. 2. The curves of either figure may be used, depending upon convenience. The instructions for use given below Fig. 1 apply also to Fig. 2.

The reactance to be used with the curves for any kind of a fault may be obtained by means of analytical calculation, by the use of the calculating board, or, if the initial values of symmetrical short-circuit currents happen to be known from other sources, indirectly by substitution in the formulas below Fig. 1. In order to choose the proper decrement curve it is essential that the reactance used to select a curve in Fig. 2, or a line in Fig. 1, be expressed as a per cent of the total connected synchronous capacity in kilovoltamperes rather than as is common practise, an arbitrary value conveniently chosen to expedite system calculations.

If the system open circuit time constant T'_{do} referred to the point of fault is known to be other than 5.0 sec., the time scale of the curves may be corrected to conform to it by means of the formula given below Fig. 1. Other information on this subject may be found in references 4 and 5.

Three Phase Short Circuit

The reactance to be used to select the proper decrement curve for a three phase fault, is what is commonly spoken of as the "system reactance" referred to or viewed from the point of fault. It is the reactance used with the decrement curves formerly published. When determining this reactance it is important that synchronous machines be represented by their subtransient reactances, and that all loads other than synchronous be neglected. Proper account has been taken of these loads for the average system in deriving the decrement curves.

The subtransient reactance just mentioned is the reactance to use in determining the r.m.s. initial

Table I—Typical Range and Average Values of Constants for Three Phase 60-Cycle Synchronous Machines

	x_d	x_d''	x_2	x_0*
Turbine-generators	0.95 to 1.45 (avg. 1.10)	0.07 to 0.17 (avg. 0.12)	$= x_d''$	0.01 to 0.14 (avg. 0.03)
Salient pole motors and generators (with amortisseurs)	0.60 to 1.45 (avg. 1.10)	0.13 to 0.35 (avg. 0.22)	$= x_d''$ (nearly)	0.02 to 0.20 (avg. 0.06)
Waterwheel generators (no amortisseurs)	0.60 to 1.45 (avg. 1.10)	$0.85x_d'$	0.30 to 0.70 (avg. 0.50)	0.04 to 0.22 (avg. 0.07)
Condensers	1.50 to 2.20 (avg. 1.80)	0.18 to 0.38 (avg. 0.25)	0.17 to 0.37 (avg. 0.24)	0.02 to 0.15 (avg. 0.08)

Nomenclature
x_d = direct axis synchronous reactance (unsaturated)
x_d' = direct axis transient reactance (saturated)
x_d'' = direct axis subtransient reactance (saturated)
x_1 = positive sequence reactance
x_2 = negative sequence reactance
x_0 = zero sequence reactance (saturated)

Supplementary Data
For test data of specific machines, refer to bibliography item 14.
x_d' = for waterwheel generators (saturated) = 0.20 to 0.45 (avg. 0.35)
x_d'' = for turbine-generators and salient pole machines with amortisseurs (saturated) from Fig. 3
*x_0 varies so critically with armature winding pitch that the average values given are not very dependable.

value of the a-c. component of short-circuit current. It includes the effect of induced currents in damper windings, etc., which have a very rapid decrement. The transient reactance on the other hand determines the a-c. component when the rapidly decaying component is neglected, while the synchronous reactance is used to determine sustained values of current.

Means for obtaining the system reactance referred to the point of fault, and the corresponding short-circuit current has been developed fully in other papers[6-11] and is not discussed here. In case synchronous machine reactances or time constants are not known, Table I and Figs. 4 and 5 may be used as a guide in selecting reasonable values.

The system reactance referred to the point of fault assists in the selection of the proper decrement curves which gives the three phase r.m.s. short-circuit current or kva. in "times normal" at any time after the occurrence of the short circuit, subject to the assumptions previously given.

Line-to-Line Short Circuit

For a line-to-line short circuit the fault current is determined by the use of the standard decrement curves of Figs. 1 and 2 in the same manner as the three-phase short-circuit current by using a reactance equal to twice the system reactance (the value used for three-phase short-circuit calculation) and multiplying the resulting current in times normal read from the curves by $\sqrt{3}$. This rule results from the theory of symmetrical components,[7,8,9,11] assuming the negative phase sequence reactance of the system as measured from the point of fault to be equal to the system reactance x_1. Where the negative phase sequence of the system is known, more accurate results may be obtained by using a reactance equal to the sum of the system reactance x_1 and the negative phase sequence system reactance x_2 instead of twice the system reactance x_1. The negative phase sequence reactance of the system is obtained in the same manner as the system reactance x_1 except that the negative phase sequence reactance of the machines is substituted for the subtransient reactance of machines.

Line-to-Ground Fault

For line-to-ground faults, the decrement curves of Figs. 1 and 2 still may be used, provided the ratio of the instantaneous values of three-phase fault current to line-to-ground fault current, or the proper value of reactance, is known. For this case the reactance may be taken as three times the system reactance ($3\ x_1$) multiplied by the ratio of the three phase current to the line-to-ground short-circuit current. Ordinarily the line-to-ground short-circuit current must be calculated by the method of symmetrical components or the reactances for the different sequences used as outlined in the paragraph following. At any time the line-to-ground current will be equal to three times the value of "times normal current" read from the decrement curves using the above values for system reactances.

The value of reactance to be used with the curves for a line-to-ground short circuit may be determined, using the method of symmetrical components, the reactance being taken as the sum of the positive, negative, and zero sequence reactances of the system ($x_1 + x_2 + x_0$) as measured from the point of fault. For ordinary calculations it is sufficiently close to use a reactance equal to $2\ x_1 + x_0$, where x is the system reactance used for three-phase short-circuit calculations and x_0 is the zero phase sequence reactance of the system. The zero phase sequence reactance may be obtained in a manner similar to that used for the determination of the system reactance for three phase short circuits by changing the reactances in accordance with the following rules:

Ungrounded transformers	= ∞
*Grounded Δ-Y transformers	= ordinary reactance to neutral on Y side and open-circuited on Δ side
Neutral impedance	= $3 \times$ actual impedance in neutral
Single circuit aerial lines (no ground wires)	= $3.5 \times$ ordinary reactance
Double circuit aerial lines (no ground wires)	= $5.5 \times$ ordinary reactance of double line
Single-circuit aerial lines (copper or aluminum ground wires)	= $2.0 \times$ ordinary reactance
Double circuit aerial lines (copper or aluminum ground wires)	= $3.0 \times$ ordinary reactance of single line
Cables, three phase	= 3 to $5 \times$ ordinary reactance
Cables, single phase	= $1.0 \times$ ordinary reactance

*Replace by circuit which permits current to flow from Y side to ground but not on Δ side.

For auto-transformers, grounding transformers, and other special apparatus, refer to papers and articles which discuss the determination of the zero phase sequence impedance in more detail.[8,12,13]

Minimum Fault Current

For certain relay applications it is sometimes necessary to know the total r.m.s. alternating fault current, *i. e.*, with no d-c. component, rather than the maxi-

Table II—Initial R.M.S. Alternating (Symmetrical) Current

Reactance on decrement curve	8	10	12	15	20
Initial symmetrical current	12.3	9.96	8.38	6.88	5.11
Reactance on decrement curve	30	40	50	75	100
Initial symmetrical current	3.37	2.52	2.01	1.33	1.00

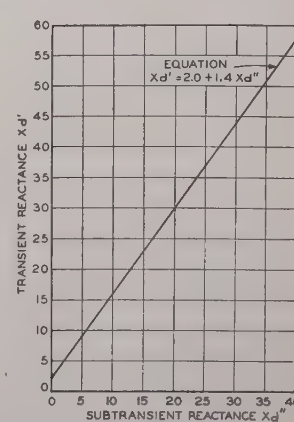


Fig. 3. Relation between x_d' and x_d'' (saturated values) for three phase synchronous machines

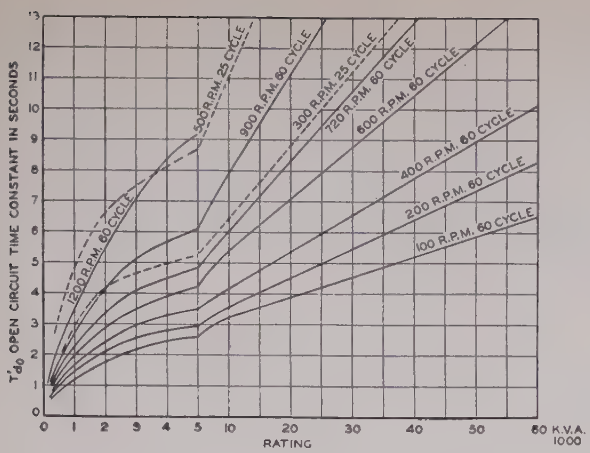
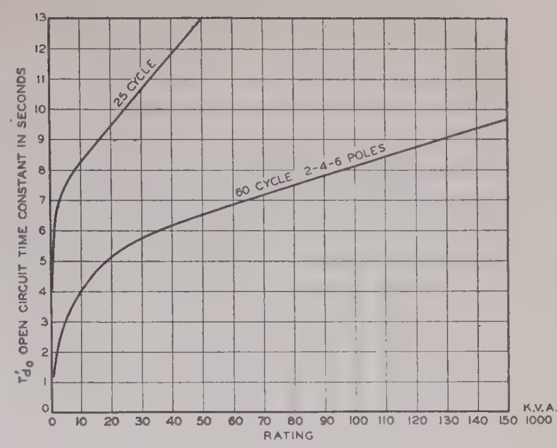


Fig. 4. (Left) Open-circuit time constants of a-c. generators and motors

Fig. 5. (Right) Open-circuit time constants of turbine generators



mum current at any time as given by the standard decrement curves which are based upon an asymmetrical fault. The initial r.m.s. alternating (symmetrical) currents for values of system reactance are given in Table II.

As the asymmetrical component is negligible after 0.3 sec., the r.m.s. alternating (symmetrical) current for any time less than 0.3 sec. may be obtained by interpolation between the initial value obtained from the above table and the curve values at 0.3 sec. Satisfactory results can be obtained readily by sketching in a curve starting from the initial r.m.s. alternating (symmetrical) current and making it tangent to the corresponding standard decrement curve at 0.3 sec.

Salient Pole Machines without Dampers

Where salient pole machines without damper windings supply the short-circuit current the standard decrement curves give good results after 0.2 sec., provided that for these machines the equivalent subtransient reactances are obtained from the known transient reactances by means of the relation given in Fig. 3; however, the initial values indicated by standard decrement curves may be 30 per cent too high. If more accurate values of initial current are desired, it is necessary to make a separate calculation of the system reactance using the actual value of the subtransient reactance of the salient pole machines without damper windings instead of the equivalent value obtained from the transient reactance by means of the relation given in Fig. 3. A curve readily may be sketched between the new initial point and the 0.2 sec. point on the standard decrement curve corresponding to the equivalent subtransient reactance of Fig. 3.

The subtransient reactance of machines without damper windings generally has been taken as equal to the transient reactance. However, there is an appreciable subtransient component in the short-circuit current of such a machine due to the damping action of the pole rivets and other closed circuits, and also due to the rapidly disappearing effects of saturation. The test data available indicate that the subtransient reactance of a machine without damper windings should be taken as about 85 per cent of the transient reactance.

Limitations of the Standard Curves

There are certain limitations in the application of standard decrement curves that should be recognized. The decrement curves with the supplementary methods will give safe values for circuit breaker application, except possibly in unusual cases. However, for relay application, it is frequently insufficient to know that the current does not exceed a particular maximum value but instead it is important to know the minimum current values under given fault conditions. In deriving the curves, it was assumed that the system could be replaced by a single equivalent generator. If the initial currents supplied to the fault by the several machines are not in proportion to their ratings, then the division of the sustained currents will not be proportional to the initial current division. Furthermore, the total current will actually be considerably smaller. For example, if a large part of the initial short-circuit current is supplied by a machine the rating of which is a small fraction of the total kva., the curve may give a sustained value that is more than 100 per cent too high. It has been assumed also that the system is fully loaded, so that if the decrement curves are used in the case of a system which is only partially loaded, it is evident that the sustained current will be less than the values given by the curves. Further it has been assumed that all of the generated e.m.f.'s are in phase. Departures under operating conditions from this assumption result in smaller values of current.

When voltage regulators are used there will be a tendency to increase the current over that given by the decrement curves. For the first 0.2 sec. the fault current will ordinarily be unaffected but the sustained current may be increased in proportion to the ratio of the maximum exciter voltage to the nominal exciter voltage corresponding to rated voltage and kva. at 80 per cent power factor. For ordinary excitation systems, *i. e.*, where quick response systems are not used, the sustained currents may be increased as much as 50 per cent by the action of the voltage regulators.

In general, for systems with characteristics radically different from the assumptions upon which the standard curves are based it may be necessary to use more accurate methods of calculation. (*Editor's note*—Steps toward the refinement of such methods

have been taken and are presented in references 2 and 3.)

EXAMPLES

The following two numerical examples illustrate the manner in which the standard decrement curves are used. For the first illustration let it be assumed that the system voltage is 66 kv. and the following data have been obtained either analytically or by use of a calculating board:

Total connected synchronous capacity	=	5,500 kva.
Initial r.m.s. alternating component, three-phase short-circuit current......	=	480 amperes (55,000 kva.)
Initial r.m.s. alternating component of line-to-ground short-circuit current...	=	570 amperes (65,000 kva.)

(The short-circuit kva. for a line-to-ground fault is equal to $\sqrt{3}$ times the product of fault current and system voltage.)

The system reactance is then

$$\frac{5{,}500}{55{,}000} \times 100 = 10 \text{ per cent}$$

The three-phase short-circuit current at 0.3 sec. is desired. Referring to Fig. 2 and following along the 10 per cent reactance curve to 0.3 sec. time it is found that at this time the short-circuit current or kva. is 5.6 times normal. Thus the short circuit kva. at 0.3 sec. is

$$5.6 \times 5{,}500 = 30{,}800 \text{ kva.}$$

Since the short circuit occurred on a 66-kv. line, the corresponding short-circuit current is

$$\frac{30{,}800}{66 \times \sqrt{3}} = 269 \text{ amperes}$$

If the equivalent open-circuit time constant of the system is 3.0 sec. instead of 5.0 sec. then the time to be used with the curves corresponding to 0.3 sec. is in accordance with the formula given below, Fig. 1.

$$0.3 \times \frac{5.0}{3.0} = 0.5 \text{ sec.}$$

For this value of time a value of 4.3 times normal is read from the curve, and the three-phase short-circuit kva. at 0.3 sec. becomes

$$4.3 \times 5{,}500 = 23{,}600 \text{ kva.}$$

For a line-to-line short circuit the reactance to be used with the curves is twice the system reactance used to find the three-phase short-circuit kva. It is

$$10 \text{ per cent} \times 2 = 20 \text{ per cent}$$

This reactance at 0.5 sec. on the curve of Fig. 2 gives 3.3 times normal, which when multiplied by $\sqrt{3}$ is 5.72 times normal. The magnitude of the line-to-line short circuit at 0.3 sec. is then

$$5.72 \times 5{,}500 = 31{,}500 \text{ kva.}$$

The line-to-ground short-circuit reactance is found from the formula on the curve sheet as

$$\frac{3 \times 65{,}000}{55{,}000} \times 10 = 35.5 \text{ per cent}$$

The line-to-ground short-circuit kva. is found by interpolation for 0.5 sec. to be 2.2 times normal which multiplied by 3 gives 6.6 times normal as the line-to-ground short-circuit kva. at 0.3 sec., *i. e.*,

$$6.6 \times 5{,}500 = 36{,}300 \text{ kva.}$$

Since this fault occurred on a 66-kv. line the line-to-line ground short-circuit current at 0.3 sec. is

$$\frac{36{,}300}{66 \times \sqrt{3}} = 317 \text{ amperes}$$

As a second illustration, a system having only water-wheel generators without amortisseur windings will be considered. The system has a total synchronous capacity of 8,000 kva., a transient reactance of 38 per cent, of which 15 per cent is external, and an open-circuit time constant of 5 sec. The three-phase short-circuit currents at 0.1 and 2.0 sec. are desired.

The curves of Fig. 2 give the decrement after 0.2 sec. quite accurately if the proper transient reactance is used to select the curve. Referring to Fig. 3 the subtransient reactance corresponding to a machine transient reactance of 23 per cent is 15 per cent. The system equivalent subtransient reactance is

$$15 \text{ per cent} + 15 \text{ per cent} = 30 \text{ per cent}$$

Using the 30 per cent curve of Fig. 2, the times normal value at 2.0 sec. is found to be 1.9. Thus the three phase short circuit is

$$1.9 \times 8{,}000 = 15{,}200 \text{ kva.}$$

The more accurate method is necessary in determining the short-circuit current at 0.1 sec. By referring to Table I it is found that the subtransient reactance of a waterwheel generator without an amortisseur is about 85 per cent of its transient reactance. So this equivalent waterwheel generator machine has a subtransient reactance of

$$23 \times 0.85 = 19.6 \text{ per cent}$$

Adding to this the external reactance, the system subtransient reactance which determines the initial short-circuit current is obtained:

$$19.6 + 15 = 34.6 \text{ per cent}$$

By interpolation between the curves of Fig. 2, the initial three phase short circuit is found to be 4.8 times normal. From the curve sketched in connecting this value to the 30 per cent curve at 0.2 sec. it is found that the three-phase short-circuit kva. at 0.1 sec. is 3.7 times normal. It is

$$3.7 \times 8{,}000 = 29{,}600 \text{ kva.}$$

The short-circuit currents may be found as in the preceding problem.

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A-C. Supervisory Control System

A supervisory control system operating entirely on alternating current and possessing great reliability is described in this article. With a suitable switchboard arrangement, the operator is said to be able to visualize switching conditions at a glance; the system has the further advantage of employing only equipment with which operators are familiar.

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BECAUSE of the rapid extension of electric power systems and the progress of electrification of railroads, the control engineer has been called upon to provide solutions to increasingly intricate control problems. Coordination between those operations led to their concentration into the hands of a single operator or dispatcher, and the adoption of automatic and of remotely controlled substations. In order to be able to control equipment located at appreciable distances it was necessary to reduce to a minimum the number of wires required for transmitting a large number of different signals; this led to the adoption of different designs of supervisory control. At the time of the adoption of those systems it was felt that only a d-c. system operating from a battery would be sufficiently reliable, as a system directly supplied by the power lines to be controlled would be affected by disturbances in these lines, at times when supervision most urgently is required.

Operating on alternating current the system described in this article thus is something of an innovation. Different means may be used for insuring a dependable a-c. supply: The supply can be obtained in any of the interconnected stations, and may consist of a small motor-generator set, supplied from the station battery. This may be dispensed with, however, if the house supply of a generating station can be made available, as this supply is not affected by any disturbances to the high voltage lines feeding the controlled substations. Another alternative is to obtain voltage from the power lines at the controlling station and at each controlled substation if these latter are fed from the same power system. In this case the supervisory system will be dead only if the power fails simultaneously at all feeding points. In either case disturbances in the low voltage side of the controlled substations will not affect the supervisory system.

In networks with many internal connections it may be felt that the presence of normal voltage on the substation bus may be depended on at all times, so that each station can be supplied independently of each other, thereby eliminating the necessity of running two supply line wires between stations; a single return wire then can be used instead. In some cases an additional degree of safety can be obtained if a supervisory control system of this kind is supplied from one high voltage network while controlling another independent network. Each individual case will indicate the best current supply to be used.

Great reliability has been the attribute most sought in the development of this control system. It employs equipment of a sturdy type used in the past in relay applications; such apparatus is little subject to disturbance by even severe inductive interference, and further it can be protected from disturbances by the insertion of insulating transformers into the lines. The system is of the synchronous selector type, each station comprising one selector, started from its rest position when an operation is to be performed, and returned to this position after the operation has been completed. In Fig. 1 is shown diagrammatically the connections of a controlling station *I* and a controlled station *II* connected by five line wires. Equipment sufficient

Based upon "An A-C. Supervisory Control System" (No. 31-91) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22–26, 1931.

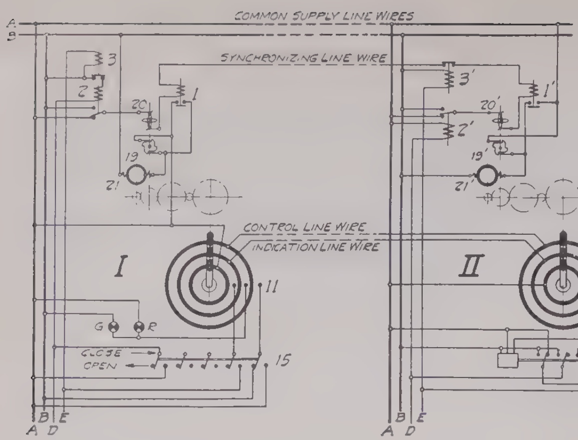

Fig. 1. Simplified diagram of a-c. supervisory system

only for illustrating the principle of operation of the selectors and the control of a circuit beaker is included in this diagram.

Selectors have been built with as many as 67 operating positions. These selectors are driven by a motor of remarkable simplicity and reliability, and one which has proved its worth in many years of service in central station and substation relays. (See Fig. 2.) It has been found that an operating time of from $^1/_3$ to $^1/_2$ sec. per step permits satisfactory operation of all the relays.

Referring to the simplified circuit of Fig. 1, the controlling station is assumed to be provided with an a-c. source supplying auxiliary busbars *A* and *B* and, over supply line wires, a set of similar auxiliary busbars, in the controlled station. Each station possesses also a starting bus *D* and a stopping bus *E* for controlling the operation of the selectors. If the selector arms are assumed to be in the rest position, as shown in Fig. 1, and it is desired to close circuit breaker *17*, control switch *15* of the circuit breaker is moved to the "close" position. This control switch is provided with several contacts, one of which connects starting bus *D* to busbar *A*, thereby energizing starting relay *2*. Until the starting relay is energized, the synchronizing line wire is connected to busbar *A* in both stations *I* and *II*, and therefore is without current. When the starting relay *2* operates, it connects one end of the synchronizing line to busbar *B*; the synchronizing line thus receives current, energizing selector relays *1* and *1′*. The latter connect to the busbars the selector motors *21* and *21′*, which start to rotate. This rotation is transmitted to contacts *19* and *19′*, which first connect the motors directly to the busbars, to contacts *20* and *20′* which open the synchronizing line, and through the two-tooth pinions to the selector arms which move to the first step. When this step is reached, contacts *20* and *20′* first reclose the synchronizing line, and contacts *19* and *19′* then disconnect the motors from the busbars. Starting relay *2* still being closed, another current impulse is sent over the synchronizing line, reenergizing selector relays *1* and *1′* before contacts *19* and *19′* open, thereby initiating another one step motion of the selector arms through the same sequence of operations.

Each selector arm thus can leave a step only if this step also has been reached by the other selector arm; motion of the selectors is obtained independently until they both again reach the following step. If one of the selectors should fail to operate while between two steps, the other selector would be unable to proceed; means are provided also for stopping the selectors if either one should jam on a step or fail to return to its rest position. In normal operation the two selector arms proceed over the

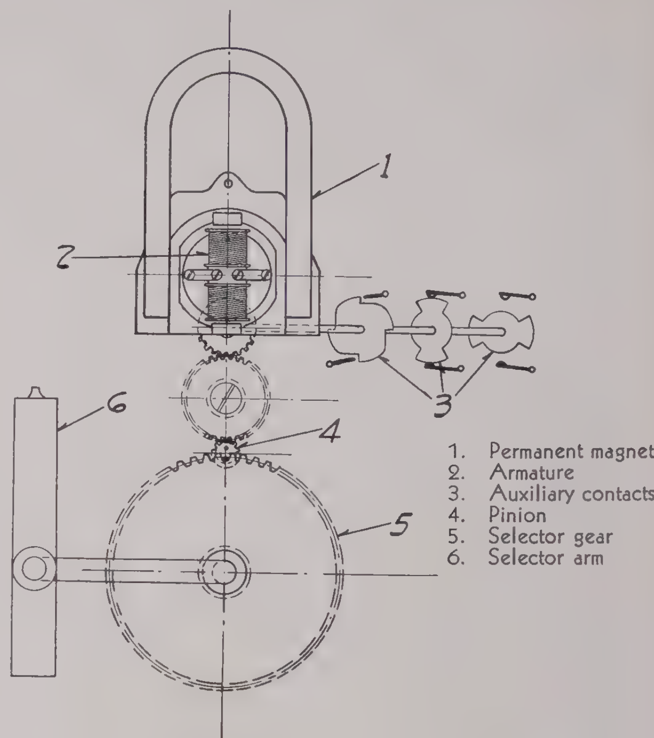

Fig. 2. Selector motor and driving mechanism

successive steps without stopping until both reach the step assigned for the control of circuit breaker *17*.

One of the brushes of selector *II* then connects busbar *A* through the control switch to the stopping bus *E*; stopping relay *3* then is energized and opens the circuit of starting relay *2*, which reconnects the synchronizing line to busbar *A* as when the system was at rest. Selector relays *1* and *1′* therefore are deenergized and the selector arms remain at standstill. Another brush of selector *II* then sends the control impulse over the control line wire and over selector *12* to the control circuit of the circuit breaker, causing it to close; the circuit breaker auxiliary contacts then send an indicating signal back over the indicating line wire.

When the circuit breaker trips automatically, it energizes starting relay *2′* which sets the two selectors in motion, in the same manner as when starting relay *2* is energized. The two selectors are stopped by means of stopping relay *3′* the return indication then being transmitted over the indicating line wire. The operator must acknowledge the tripping by moving the breaker control switch to the "open" position, and suitable relays prevent the initiation of a control operation or even the comple-

tion of an operation initiated before the tripping, until such acknowledgment is made. Thus when the operator wishes to perform a control operation, he is assured positively that while that operation is being completed, the equipment which this operation does not affect will still be in the condition shown by the indications on his switchboard. At the same time, this condition can be the result only of operations either initiated or acknowledged by himself by means of his control switches. In this manner the danger of the operator becoming confused and performing undesired operations is reduced to a minimum.

After an operation is completed, the selectors are returned by suitable relays to their rest positions. In addition to the foregoing provisions, proper control of a circuit breaker requires means for preventing automatic reclosing after tripping and consequent "pumping"; to take care of this, automatic tripping is indicated to the operator by blinking of the control lamp and by the ringing of a bell.

Fig. 3. Rear view of partially assembled luminous switchboard

Analogous circuits can be provided for other control and supervision operations such as the reading of meter indications, automatic position indication of manually operated disconnecting switches, alarm indications to warn of excessive temperatures, or other disturbances in the substation. The system can be modified easily to meet local conditions, and a single selector in the controlling station can be used for controlling several selectors in outlying stations.

Control switches, selectors, control lamps, and the various relays, can be mounted in different ways on switchboards or control desks. A suggested disposition applicable both to manual and to supervisory control which enables the operator to visualize at all times the condition of the system which he is controlling, is described as follows: The control switches are installed on a switch desk in front of the switchboard the handles of the switches forming part of a set of dummy buses so that the positions of all circuit breakers can be visualized. The switchboard is built from sheets of glass covered by an opaque paint leaving transparencies which form a diagram of the buses and lines duplicating the dummy set of buses on the switch desk. Indicating lamps are disposed behind the switchboard so as to show in proper colors the positions of the circuit breakers. Additional indicating lamps indicate whether or not the buses and lines are energized, for which purpose they are controlled by suitable relays connected to the circuit breaker controlling circuits. Additional transparencies provided in the lines can be used for indicating the readings of ammeters, voltmeters, or other instruments. Each of these transparencies discloses a meter box having a ground glass front graduated so as to provide a scale on which the readings are given by the shadow of the moving element of one or of several instruments. In this manner each meter is so located that it is immediately apparent to which circuit the reading refers. (See Figs. 3 and 4.)

This method of enabling the operator to visualize at a glance the condition of the network and the changes occurring therein, the position of the switching equipment, and the location of meter reading, greatly facilitates the supervisory operations and reduces the chances of performing wrong operations. In addition, the equipment is of a type with which the operators and maintenance crews are familiar, so that no special training is required for the personnel. These two advantages together with the flexibility and reliability of the equipment should make this system of particular interest to operating engineers.

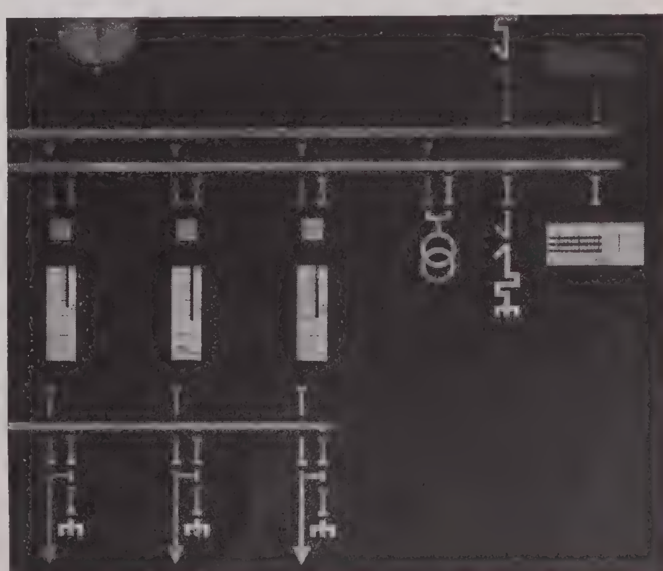

Fig. 4. Front view of a section of luminous switchboard with three feeder ammeters and bus voltmeter

A New Carrier Telephone Cable

Three carrier telephone circuits and one telegraph circuit are provided by this newest cable linking the United States with Cuba. The design is such that still more carrier channels may be provided when the need for them arises.

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COMMUNICATION has advanced in many respects during the past decade. In carrier current communication over submarine cables this advance has been such that three telephone circuits are provided over the new Key West-Havana cable where each of the three earlier cables, installed ten years ago, provide only one. Furthermore, the new cable is but little larger than the three previously installed. ("Key West-Havana Submarine Telephone Cable System," A.I.E.E. Trans., v. 41, 1922, p. 1–19.) This latest cable was placed in service in January 1931, and like the three cables just mentioned is owned by the Cuban-American Telephone and Telegraph Company, an organization controlled jointly by the American Telephone and Telegraph Company and the Cuban Telephone Company, and providing telephone facilities between the United States and Cuba.

The new cable, which has been designated the 1930 cable is the longest deep sea telephone cable in existence; also it is unique in being the longest telephone cable circuit without intermediate repeaters and without inductive loading. It is about 3.7 nautical miles (1 nautical mile = 6,087 ft.) longer than the longest of the 1921 cables. The design of the cable is such as to satisfy economically the need for more circuits by an adaptation of standard carrier apparatus. The design was made sufficiently liberal, however, so that certain further development work would make it possible to obtain over the same cable still more facilities when these are required.

From a transmission standpoint, the feature of most interest is the unusually low receiving levels at which operation is carried on successfully. (See Fig. 1.) Of importance also is the fact that the new cable is operated over a far wider frequency range than are the older cables. Whereas the old cables are operated only up to 3,800 cycles per sec., the new cable at present is being operated at frequencies as high as 28,000 cycles per sec., and can operate at still higher frequencies.

Paragutta Insulation Used

Paragutta insulation is the feature of the new cable which has enabled such great improvement to be attained. This material developed at the Bell Telephone Laboratories is composed of deproteinized rubber, deresinated balata, and wax. It has been described in detail by A. R. Kemp ("Paragutta, A New Insulating Material for Submarine Cables," *Jl. of the Franklin Inst.*, v. 211, Jan. 1931, p. 37). Heretofore submarine cables having waterproof insulation have almost invariably been insulated with gutta-percha or balata, or a mixture of these substances; an exception to this is the Catalina Island cables which are insulated with a special rubber mixture ("Carrier Current Communication on Submarine Cables," H. W. Hitchcock, A.I.E.E. Trans., v. 45, 1926, p. 923–9). Paragutta has better electrical properties than any of these materials.

As shown by Table I, paragutta possesses a smaller dielectric constant and a smaller leakance than

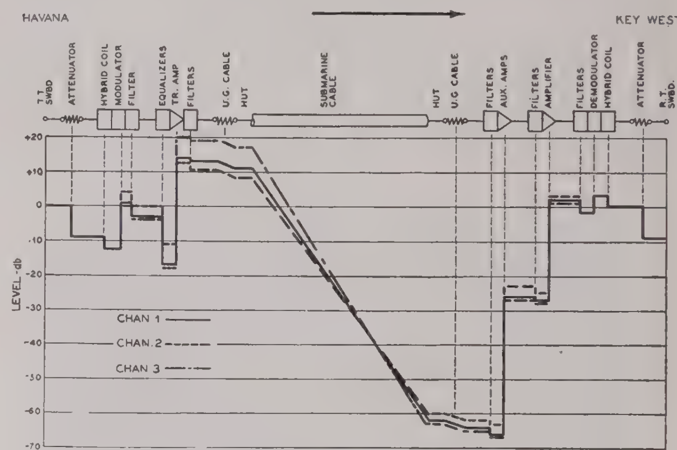

Fig. 1. Relative transmission levels in 1930 Key West-Havana submarine telephone circuit

Energy level at the toll switchboard on the left is taken as zero

Table I—Comparative Properties of Gutta-Percha and Paragutta Insulations

	Dielectric Constant	Ratio of Leakance to Capacitance
Gutta-percha (telegraph cable)	3.3	4,040
Gutta-percha as used in 1921 Key West-Havana Cables	3.1	——
Gutta-percha as used in Tenerife-Gran Canaria and Algeciras-Ceuta Telephone Cables*	2.92	3,815
Paragutta (Key West-Havana 1930 Cable)	2.67	229

Measurements made at 22 kc. per sec. under sea bottom conditions.
**Electrical Communication*, v. 9, 1931, p. 217.

Based upon "A New Key West-Havana Carrier Telephone Cable," presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

gutta-percha. (The term leakance as used here includes all energy losses in the dielectric.) This property permits a considerable reduction in the size of a cable for a given attenuation. The decrease in size due to the use of paragutta varies of course with the size of the cable, but some idea of its amount may be obtained from the fact that a cable insulated with gutta-percha of the sort used in the 1921 cables would weigh 45 per cent more and cost about 65 per cent more than the new cable.

Use of this new material in the manufacture of a cable gave rise to numerous problems, one of which, namely that of jointing the paragutta, deserves particular mention. In this connection a new technique of jointing was developed which not only produces good joints in paragutta-insulated cable, but also produces better joints in gutta-percha-insulated cable than can be made by the conventional process which has been in general use since the latter were first manufactured.

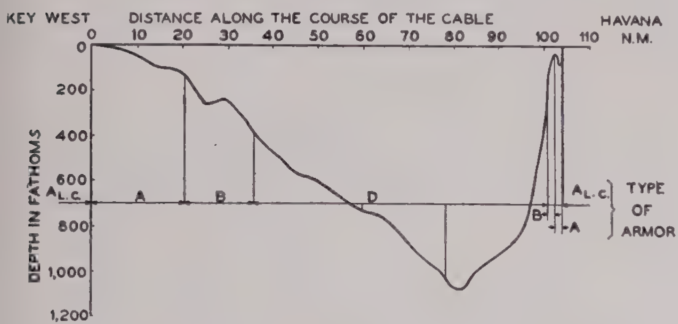

Fig. 2. Profile of route of 1930 cable; a fathom is equal to 6 ft.

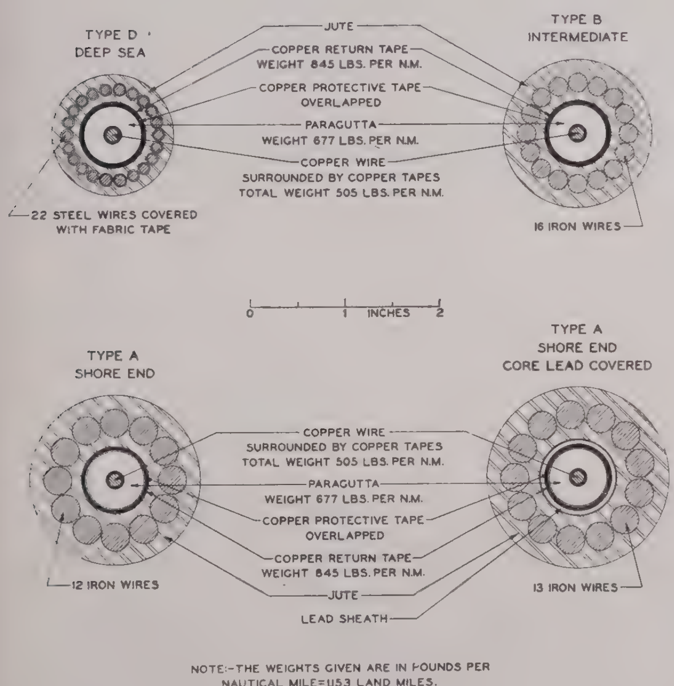

Fig. 3. Cross-sections of cables used at various depths (see Fig. 2)

Cable Design

Except that it is not loaded, the new cable is similar in type to the 1921 cables. It is provided with copper return tapes ("Transmission Characteristics of the Submarine Cable," Carson and Gilbert, *Jl. of the Franklin Inst.*, v. 192, 1921, p. 705) and also with a thin copper tape under the return tapes for protection against marine organisms. The lay, or pitch, of the return tapes was made much longer ("U. S. Patent No. 1,700,476," Jan. 29, 1929) than in the 1921 cables. This brought about a substantial decrease in the effective resistance of the tapes themselves and reduced the eddy current losses which are due to the helical nature of the return tapes. Thickness of the insulation is much greater ("British Patent No. 343,093," May 7, 1931) compared with the diameter of the central conductor than is the case with low frequency cables, either telephone or telegraph.

In all matters of mechanical design, accepted cable practise was followed. A discussion of some of the mechanical features of cable design as well as some account of the general submarine cable problem has been given in the paper referred to in the first paragraph of this article.

Length of the new cable is 108.6 nautical miles (125.2 statute miles). It was manufactured by the Norddeutsche Seekabelwerke-A.G. of Nordenham, Germany, and laid by its cable steamer "Neptun." The maximum depth attained is 1,080 fathoms (6,480 ft.) as may be seen from Fig. 2. Cross-sections of the various types of cable used at different depths are shown in Fig. 3.

At carrier frequencies the effect of the armor wire is negligible from the standpoints of magnetic modulation and attenuation. Attenuation of the cable (see Fig. 4) is characteristic of a non-loaded cable in that it increases rapidly at low frequencies but less rapidly at high frequencies whereas in general the reverse is true of the loaded cable. Against electrical interference, but little shielding is needed beyond that furnished naturally by the sea water; the small additional shielding required is furnished by a wrought iron pipe enclosing the cable between the cable hut and the level of the lowest tides.

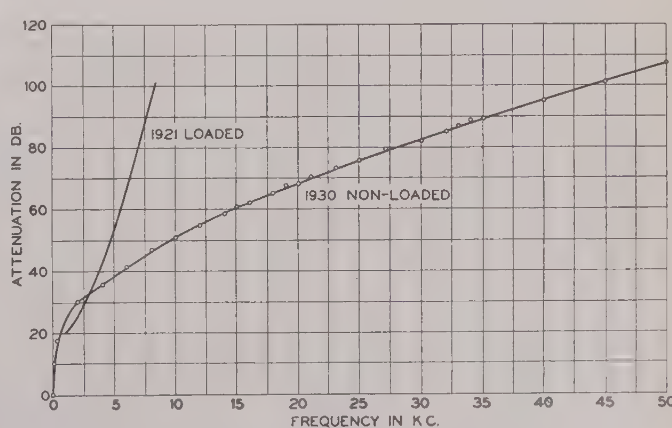

Fig. 4. Frequency-attenuation characteristics of 1921 and 1930 cables

Carrier System

As noted previously, the three present telephone channels are obtained by an adaptation of carrier apparatus ordinarily used for long distance transmission over open-wire lines ("Carrier Systems on Long Distance Telephone Lines," Affel, Demarest, and Green, A.I.E.E. Trans., v. 47, 1928, p. 1360–86). Special additional equipment consisting chiefly of receiving amplifiers and directional filters was added to care for the greater gain and selectivity needed to operate over the higher attenuation.

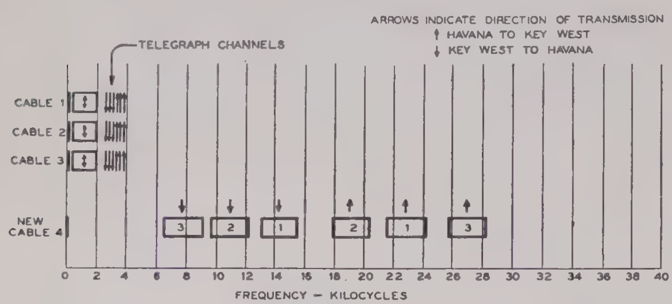

Fig. 5. Frequency allocation of communication channels in Key West-Havana cables

The six frequency bands (one for each direction for the three channels) are allocated as shown in Fig. 5; a d-c. telegraph channel also is indicated. This chart likewise shows the frequency allocation of the one telephone and four telegraph channels (three carrier and one d-c.) now carried over each of the three older cables. It may be noted that the frequency band width of the new telephone channels is much greater than that of the old ones, thus furnishing higher quality speech transmission. In addition, a large range of frequencies remains unused on the new cable; this range may be developed when additional message telephone, broadcasting, or telegraph facilities are needed.

Carrier apparatus is installed in existing telephone offices at Key West and Havana. In each case the office is somewhat over one mile from the cable but at the water's edge. The submarine cable circuit is connected to the apparatus in the offices through pairs of wire in an underground cable of the paper-insulated lead-covered type, which carries also the circuits of the older cables. In Fig. 6 is shown schematically the connections of the apparatus at the Havana end of the cable. The arrangements are practically identical at the two terminals except for differences incident to the fact that different frequency bands are transmitted in the opposite directions.

Some Transmission Problems

Satisfactory transmission over high cable attenuation involves several especially critical points. First of all, the transmitting amplifier must amplify to the high levels required without modulating sufficiently to produce troublesome new frequencies falling within its own group of frequency bands. New frequencies produced by the amplifier which fall outside of this group are suppressed by directional filters and cause no trouble.

Additional possible sources of modulation are the directional filters and impedance matching transformers; these must transmit the high levels coming from the amplifier but must not modulate them sufficiently to produce troublesome new frequencies falling within the oppositely directed group of bands. The latter are at an exceedingly low level and so the modulation in these circuit elements must be kept extremely small. Some ordinary resistances, mica condensers, and other apparatus,

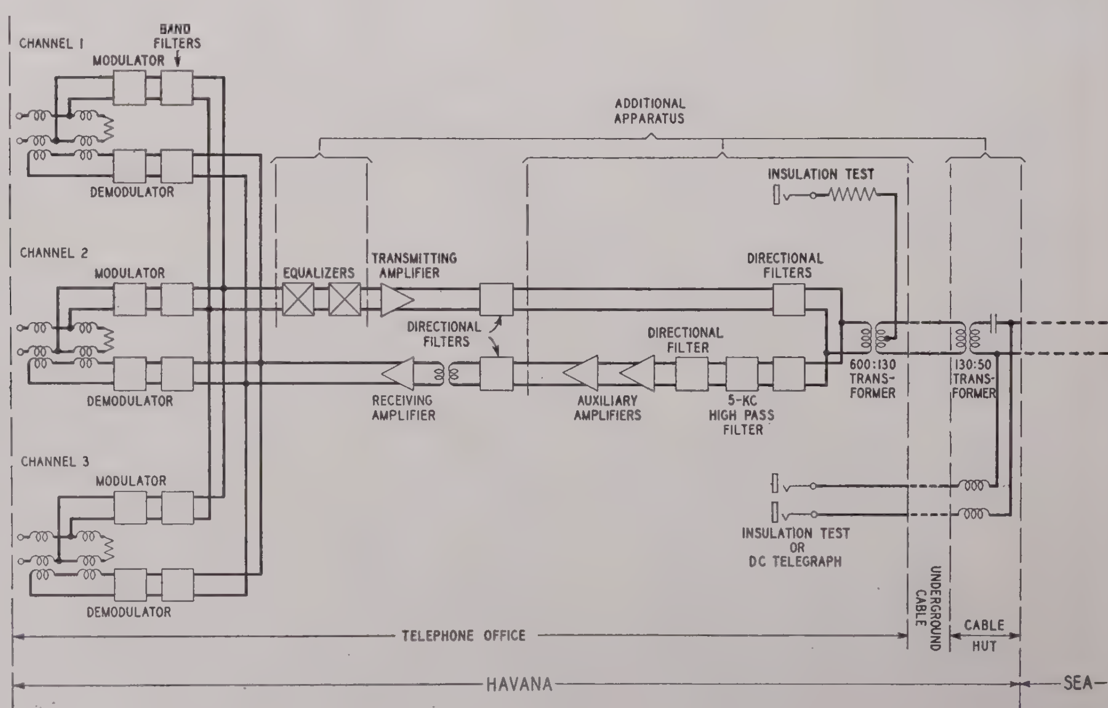

Fig. 6. Schematic diagram of carrier system used on the Havana end of the 1930 cable. Apparatus used on the Key West end is similar except of course it is designed for different frequencies

have been found to have enough modulation to be serious. In this respect ordinary iron core transformers are likely to be extremely troublesome; hence, special design is required to reduce the modulation in the impedance matching transformers to tolerable limits.

Noise Prevention

At the cable ends the important problem naturally is to keep the low level receiving circuit free from interference. In taking the necessary precautions along these lines, many sources of noise were investigated and remedial measures provided. These included cross-talk from other carrier telephone or telegraph systems, high frequency oscillations set up by d-c. telegraph apparatus in the vicinity, radio stations, power wires, submarine telegraph cables, and many minor sources.

Of particular interest was the case where the Commercial Cable Company's submarine telegraph circuits from Havana to New York, a communication facility of low inherent frequency range, interfered with the carrier channels having frequencies up to 28 kc. This interference was found to originate by induction in the underground cable at Havana through which both circuits passed. In this case, by the generous cooperation of the Commercial Cable Company, frequency limiting equipment was added to its cable transmitter.

Electrical Units and Their Application

Progress and improvement in any art or science are not made without provision for suitable measurements. Many advances in the field of electrical units and their measurements have been scored within the past forty or fifty years. Developments in electrical measurements have been satisfactory in that they have kept slightly ahead of practical demands.

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ELECTRICAL UNITS are based upon or definitely related to units of length, mass, and time. In an ordinary sense the latter are not electrical, but because so much depends upon them it is of interest to know how definite and permanent they are; also how precisely they may be determined by reference to existing standards. Of interest also is the accuracy with which copies of the fundamental units may be made, and the degree of precision obtainable in producing for practical use multiples or submultiples of the fundamental unit chosen.

For ordinary work, accuracy of standard and precision of comparison considerably below the best obtainable are satisfactory. Workers in the field of primary reference standards, however, must be able to make determinations from 10 to 100 times more precise than those demanded in practise, so that the practical art has something to grow up to. Nevertheless, unusual practical requirements sometimes arise suddenly that can be met only with precision far greater than any previously employed. It is in this region of high precision that the national laboratories and some independent workers find a highly useful field; and in this class of work the U.S. Bureau of Standards ranks second to none.

For the fundamental units of length, mass, and time, perhaps the most familiar is the so-called c.g.s. system. In this system the centimeter is taken as the unit of length, the gram as the unit of mass, and the second as the unit of time. These units have been quite generally accepted for many years, and are likely to endure for some time to come.

Fundamental C.G.S. Units

Mass standards are permanent and can be compared with a precision of one, or at least a very few parts in 100,000,000; standards of length are about the same. These therefore lie definitely in the 10^{-8} class. (A precision of from 1 to a possible 9 parts in 100,000,000 will be called 10^{-8}, and so on down to 10^{-2}.) Time, one of the fundamental elements in many things, hardly can be regarded as in the same class as length and mass. A minimum departure of about 0.001 sec. per day from a uniform rate is required in order that a clock may be included in the 10^{-8} class. This is better than has been attained over an extended period of time. The present status of time measurements places it in the 10^{-7} class; in fact it even has a tendency to slip into the 10^{-6} class.

Roughly 500 years ago the first instruments that really could be called clocks were brought out and were quite definitely in the 10^{-2} class, although probably the lower end of this band; in 300 years clocks were brought into the 10^{-6} class; and in about 150 years more, into the 10^{-7} class. During the

Based upon "Electrical Units and Their Application" (No. 31-120) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.
* Deceased (Nov. 3, 1931).

last few years the clocks of Shortt and of Schuler, each quite different from the other, have given unmistakable signs of being able to qualify for the 10^{-8} class. This shows remarkable progress, for twice within about the last 40 years the error in timekeepers has been divided by 10.

This brief consideration of time is not really a digression, for within the last few years the demand for accurate measurement of time on which frequency or wave-length measurements are based came almost too soon. This is a definite example of the precision desired in practical measurements coming too close for comfort to the precision maintainable in primary reference standards.

The time measurement situation, however, is not without its brighter side. The crystal oscillator, which in a certain way caused the trouble by requiring accurate adjustment and timing, has been found to be itself a most reliable timing device. First checked with clocks, it now bids fair to turn about and enter the higher timekeeping class itself. Comparisons between crystal oscillators now can be placed in the 10^{-8} class, and timing of crystals in the 10^{-7} class.

This brief discussion is of interest because it indicates the present status of units and measurements of the three fundamental standards. The conclusion is that they are in a fairly satisfactory position with time far in the rear, but rapidly advancing to a position of equality with length and mass. Therefore these units form an excellent basis upon which a system of electrical units may be built. Difficulties are experienced, however, in the steps necessary to realize electrical standards from standards of length, mass, and time; no doubt improvements in methods and procedure will be made in time so that the precision assignable to the three fundamental units may be realized more nearly in the electrical units used for fundamental reference.

Electrical Units

Of primary interest in the field of electrical units are the ohm, the volt, and the ampere, or the absolute units of which these are derived multiples. As may be seen later a wide gap exists between the precision assignable to length, mass, and even time, and that assignable to the absolute values of the practical electrical units. This is so for very good reasons: Fundamental length and mass standards are in a sense arbitrary; this does not give concern because when once established such standards remain permanent within satisfactory limits. In considering electrical units, however, their relation to length, mass, and time must be known; also electrical units must not be arbitrary if agreement with mechanical and other units derived from length, mass, and time is to be maintained. Electrical standards therefore must be kept from change and at the same time must be brought into a definite and predetermined relation to the fundamental units, so that conversion factors may be as simple as possible.

The ohm now is defined as the resistance at 0 deg. cent. of a column of mercury approximately 106.30 cm. in height and having a cross-section of 1 sq. cm. The value of the ohm may be certain to five significant figures (10^{-4}) but can hardly be said to be known dependably to six figures (10^{-5}). However, work is being done constantly to better this situation. In general, copies and comparisons of resistances may be made to a precision of about 10^{-6} with a permanence of primary reference standards of about the same order.

On the basis of the foregoing, the ohm may be considered to be in a fairly satisfactory state of determination, but more certainty as to its absolute value is desirable (at least to a precision of 10^{-6}) Gratifying progress in this direction has been made. Looking back to the first ohm established by the British Association committee, this unit was about 1.5 per cent smaller than the present ohm. It has taken nearly 50 years to eliminate the greater part of this error, although most of the change was made in one important step. Precision and permanence of the ohm have just about kept out of the way of progress in the practical field.

The volt had a rather bad start; in the early days it was derived primarily from the ampere and the ohm. With much time and care, galvanometers were constructed depending for their accuracy upon measurements of length, and upon the strength of the earth's magnetic field. Here again the unit was tied up with a property of the earth as is the present unit with time; unfortunately, however, amperes cannot be transmitted by telegraphic signal or radio, and although the earth's magnetic field is capable of precise determination, the ampere or multiple of it when realized could not very well be carried home and used. Instruments then were made which did not involve a permanent magnet and which did not depend upon the earth's magnetic field. Some of these electrodynamometers were very good, but were not always dependable or precise within the required limits.

Weston Cell an Important Advance

No competitor of the galvanometer or electrodynamometer appeared until the advent of the Clark cell, although certain voltaic cells had been known for some time. The Clark cell could be reproduced in various localities with considerable precision. However, this cell had a marked temperature error, and also was fraught with other difficulties which prevented its general use. The situation regarding the volt was improved enormously, however, when Edward Weston introduced his Standard cell. It was this cell which, in one form or another, now is used, together with copies of the ohm or multiples of either or both, as the basic standard of most electrical measurements. The present status of the volt is such that it is practically in the same class as the ohm, that is the 10^{-4} class; as a result the ampere in terms of these two standards may lie perhaps in the same class. This refers to absolute values only; comparisons probably are possible to a precision of about 10^{-6}.

Using standard cells and carefully compared resistances, a class of instruments has been developed for the determination or realization of ohms, volts,

amperes, and watts. These commonly are known as bridges and potentiometers and are capable of giving multiples of the units over a wide range with a precision well up into the 10^{-5} class. These instruments are convenient to use and are permanent and reliable; they are employed primarily for the calibration of portable and working instruments. For these purposes, however, the precision of which they are capable is unnecessarily high. Still another class of instruments is represented by the deflection potentiometer, which falls perhaps in the middle part of the 10^{-4} class as regards precision.

These instruments may be used both as reference standards and for direct observations. As a result, for continuous currents it is possible at any time to secure definite and accurate measurements which in most cases excel the practical requirements in this respect.

A-C. Measurements

Many measurements must be made where alternating current is the medium; here, in special cases, the instrument commonly used employs some sort of a reflecting device for observing the indications of the moving part. As regards precision these instruments may be placed on the borderline between the 10^{-3} and 10^{-4} class, but they do not fill the requirements of this class with complete success.

Considering the instruments available for the intermediate class of work (between 10^{-5} and 10^{-3}) of which so much must be done, time and patience surely are taxed to obtain the required results. For this type of work, instruments similar to the deflection potentiometer which would be conveniently usable on alternating current, would be extremely helpful. Another factor which must be considered in this regard is the step from d-c. to a-c. measurements which rests upon the assumption that for the same r.m.s. values, a given instrument will give the same indication on alternating current as it does on direct current. This step does not in all cases rest upon a perfectly secure basis.

Use of Portable A-C. Instruments

In using portable direct-reading instruments or instruments of the intermediate class on a-c. circuits or systems, it is difficult sometimes to realize the precision of which the instruments are capable. This is because of slow pulsations in the supply source and because all moving systems have not the same time of swing. In addition, a-c. measurements of necessity involve work on rotating machinery and this fact introduces more problems. Some success has been attained by recording photographically or by other means the positions of the pointers of a group of instruments, but this is not always satisfactory; it is usually best to record enough readings to overcome the effects of fluctuations. Although in a well equipped laboratory matters can be improved greatly by using refined regulators on the supply lines, this fills but a small part of the general need.

In dealing with large values of a-c. amperes, volts, and watts, usually it is not possible to employ resistances so precisely comparable with reference standards. In this field it has become customary to employ instrument transformers. These transformers are capable of quite precise work, and when carefully checked and properly used, may be placed in the lower part of the 10^{-4} class. Instrument transformers serve the purpose also of protecting the observer from contact with the circuit voltage.

Within comparatively recent years the electrical measurement art has required expansion into the high frequency field and also into the field of very low power-factor measurements; here new requirements are met involving many curious effects which must be guarded against. The recording of wave fronts expressed in microseconds, together with a great variety of problems connected with sound and communication systems using wires and with the radio art, have been met for the most part with a fair degree of satisfaction. This general group cannot be referred to in detail; a tremendous range of voltage, current, power, and frequency must be covered from comparatively small values up to millions of volts, thousands of amperes, and millions of cycles per second.

Other Developments

Great increases in sensitivity and decreases in the amount of power required to make measurements have been made possible by the use of vacuum tubes; hence a large expansion in this field may be looked for. Permanence and reliability if they could be increased would enhance the usefulness of these methods.

Capacitors or condensers are very useful devices for, when charged with a voltage which can be determined very precisely from standard cells and suitable multiplying arrangements, they are able to give out a definite quantity of electricity. However, condensers are not permanent and reliable to the same extent as resistors and standard cells, and improvements along this line would be desirable. For example, in magnetic measurements it would be much simpler to work from a reference standard condenser than to use mutual inductances determined by some of the well-known methods of comparison, or by direct reference to length standards.

Materials for resistance standards have been improved greatly and at present there appears to be but little need for further improvement. Accuracy with which comparisons can be made is perhaps ten times greater than the precision or permanence of resistance units assembled in practical apparatus without taking undue precautions; such precautions need not be taken if the temperature effects were less than they are now.

Increased development of instruments in the intermediate class (10^{-4}) is hoped for; devices are needed which will stand in the a-c. field (at normal and if possible at high frequencies and at low power factor) in the same place that the deflection potentiometer, resistances, and standard cells occupy with respect to d-c. applications.

Among practical workers but little advance has

been made along the line of combining and weighing of results, and in the application of well-known and simple probability relations. It is possible to do much along this line; a few simple relations would cover most cases and would be of enormous advantage. Experience can develop an intuitive sense in this regard and if the results obtained with a number of determinations are made use of, and sufficient care taken to control the conditions under which the observations are made, it is surprising what can be done with comparatively crude apparatus.

SUMMARY

It is not intended that the conclusion to be drawn from this brief review is that conditions regarding electrical units are unsatisfactory. Of course the point of view might be taken that satisfactory progress has not been made in the last 50 years and that the best reference standards are not at all in the same class with available standards of length, mass, and time. Ordinary portable electrical instruments seem crude in comparison with portable and every day instruments for determining mass, length, and time; but the situation should not be regarded at all in this light. Length, mass, and time standards have had at least ten times as long a period of development as have electrical standards.

The one fundamental unit that has advanced the most is time; this advance has been about 100 fold in the past 40 years. Electrical reference standards and the precision of comparison with such standards have been advanced in relation to the fundamental units, by about the same amount in the same length of time. In the portable instrument field and in indicating instruments generally, errors have been divided by about 10 within the same period. Therefore, the situation may be reviewed with some degree of satisfaction. Progress in the field of electrical units has equaled by comparison the rate of progress in other branches, but there is still much to be done and much to be learned by occasional excursions into other lines a little outside of the electrical field. Most important of all, the interest in going forward assuredly is undiminished, and during the next few years further and important advances will be made.

The Unit of Electrical Resistance

The mercury ohm, long recognized as a standard of resistance, with its elaborate technique and many disadvantages has become obsolescent. The reasons for this, together with a brief historical sketch of the ohm, are presented in this article.

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IN SPITE OF the vast amount of high class technical labor which has been expended upon the mercury ohm it seems physically impossible to push its limit of reproducibility beyond that attained thirty years ago, namely, a few parts in 100,000. On the other hand, the technique of absolute measurements has improved continuously, until now it is at least on a par with the mercury ohm as regards reproducibility. The technique of absolute measurements undoubtedly can be improved; but even if no better than the present parity (as to reproducibility) with the mercury ohm were maintained, the latter, always a necessary evil, has no further reason for existence. Recognizing these facts the advisory committee on electricity of the International Committee of Weights and Measures, at its 1930 meeting held in Paris, adopted the following resolution:

"With regard to the unit of resistance, the ohm, considering that methods of determining the absolute ohm are sufficiently advanced and that the agreement between the measurement of the coils (secondary standards) of the different (national) laboratories remains within the limits of precision of the measurements, it is not necessary at present to undertake further comparisons of the resistance coils with mercury ohms."

In order to bring out the full significance of this seemingly radical proposal and the sound reasons for the ultimate abandonment of the mercury ohm as a legalized material standard, a brief historical review of the ohm may be of interest.

EARLY WIRE STANDARDS

After the announcement by Ohm in 1827 of his famous law, electrical workers began to feel the need for a unit of electrical resistance. As a result several arbitrary standards were suggested by different scientists, these consisting mostly of specified lengths of certain kinds of metallic wire. All of these early proposals, however, were faulty; simple metals were difficult to obtain in sufficient purity, and their resistivity was affected by internal stresses and by the degree of annealing. In addition the alloy wires advocated by some were not of definite or exactly reproducible composition.

Based upon "The Unit of Electrical Resistance: Past History and Impending Change" (No. 31-110) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22–26, 1931.

Use of mercury as an ideal metal for an electrical resistance standard seems to have been suggested first by Marie-Davy, but in 1860 Werner Siemens made the first practical proposal concerning it, namely, that the unit of resistance should be "the resistance at 0 deg. cent. of a prism of mercury 1 m. long and 1 sq. mm. in cross-section." He demonstrated that he could reproduce a unit of resistance by means of mercury in glass tubes with an error of less than 5 parts in 10,000. The unit he proposed came into use under the name *Siemens Einheit* (Siemens unit) denoted in the older literature by the abbreviation *S.E.*

In 1861 at the suggestion of Sir William Thomson (later Lord Kelvin) the British Association for the Advancement of Science appointed a committee on standards of electrical resistance. This "B.A." committee as it was known, recognized the necessity for material standards of resistance, but also desired that such standards refer ultimately to an absolute basis; such a material standard when once established was to be regarded as a prototype standard and never to be changed even though succeeding absolute measurements might show it to be appreciably in error. As the absolute basis upon which to establish the proposed standard, the committee finally adopted the centimeter-gram-second, or ordinary c.g.s. system.

B.A. Unit Established

Three members of the B.A. committee in 1863 and 1864 made absolute measurements of resistance at King's College, by rotating a short-circuited coil of copper wire about a vertical diameter and with a measured velocity, observing the resulting deflection of a magnetic needle at the center of the coil. From the known angular velocity, the deflection of the magnet, and the linear measurements of the coil, the resistance of the coil was computed in absolute units. Upon the basis of this work, the committee constructed standard coils of platinum-silver wire, and began to issue copies of the "B.A. Unit." The committee was dissolved in 1870, but in 1878 the investigations of Rowland at Baltimore showed that the B.A. unit was more than 1 per cent smaller than the value (10^9 c.g.s. electromagnetic units) which the committee had intended to give it. This result was verified soon afterward by other investigators, and in 1880 the B.A. committee was reappointed.

In the meantime several mercury standards of resistance had been set up in accordance with the proposal of Werner Siemens. From the standpoint of that time, agreement between these standards was satisfactory and the results of absolute determinations consequently had been referred directly or indirectly to the Siemens Unit.

Early Attempts to Legalize the Mercury Ohm

In 1881 an International Congress of Electricians met at Paris for the purpose of establishing definitions of the electrical units in a form suitable for enactment into legislation. This congress adopted a resolution proposing: that the ohm preserve its previous definition, namely, 10^9 c.g.s. electromagnetic units; that it be represented by a column of mercury 1 sq. mm. in cross-section, at a temperature of 0 deg. cent.; and that an international commission be charged with the determination, by new experiments, of the length of the mercury column to have a resistance of 10^9 c.g.s. electromagnetic units. At its second meeting, held at Paris in 1884, this commission known as the International Conference for the Determination of the Electrical Units, adopted 106 cm. as the length of the mercury column, in spite of the fact that the best absolute determinations indicated 106.3 cm. to be more nearly correct. This compromise with the facts was made because it was considered advisable for a provisional value to be correct to the last figure given. The unit of resistance so defined was given the misleading name *legal ohm*, but although it was used to some extent, it was never legalized.

The B.A. committee mentioned previously continued its work during the next succeeding few years, adopting the legal ohm in its standardizing work with a supplementary statement of the value of the legal ohm in B.A. units. In 1892, however, this committee discontinued issuing standards in terms of the legal ohm in favor of the ohm defined as a resistance of a column of mercury 106.3 cm. long. In the meantime this committee had experienced difficulties from variations in the relative values of its wire standards. These difficulties effectually negatived the committee's original plan for a wire standard never to be altered, and established the fact that some independent and reliable method for checking the constancy of the wire standards was required.

Mercury Ohm Adopted Internationally

Another important development came about during the Chicago Exposition of 1893, when an international electrical congress met with representatives of ten governments in attendance. This congress adopted resolutions defining eight electrical units, and to distinguish them from their predecessors these units were called *international* units. The international ohm was defined as being based upon 10^9 c.g.s. units of resistance, and as represented by the resistance offered to an unvarying electric current by a column of mercury 14.4521 g. in mass at the temperature of melting ice, having a length of 106.3 cm. and a constant cross-sectional area.

Because of certain defects and inconsistencies in the resolutions of the Chicago congress, the six national governments which afterward legislated on the matter defined the electrical units in different ways. One of the outstanding defects of the Chicago resolutions was that the ohm, ampere, and volt, which are physically related by Ohm's law, all were defined in terms of material standards.

The next international congress on electrical units and standards was held in 1908 at London, with delegates from 21 countries. At this meeting resolutions were adopted which for the first time clearly differentiated between the fundamental (absolute) electrical units, and a system of units repre-

senting the fundamental units, and sufficiently near them for practical use and to serve as a basis for legislation. Recommendations made by this conference, however, did not affect the value of the ohm; hence the international unit of resistance remained as defined at the Chicago exposition congress of 1893, and has not been altered since that time.

Time and patience required in making mercury ohm determinations are so great, however, that in spite of its legal standing, only a relatively small number of outstanding determinations have been made during the past thirty years. The elaborate technique of cleaning, calibrating, and cutting off the tubes, measuring their length, determining the mass of contained mercury, and of comparing the resistances of the tubes with existing wire standards, is too laborious and involved to be outlined here. To be worth doing at all, this technique must be carried out by scientific men of great manipulative ability, with the observance of extreme precautions against errors in various parts of the measurement.

Advantages and Disadvantages of Mercury Ohm

Principal advantages of the mercury-ohm standard are as follows: The conducting material is free from internal molecular stresses and is purifiable to a high degree. Because it can be reproduced from specifications, the mercury-ohm standard serves to record the unit of resistance of any given period within a few parts in 100,000 for future reference. The standard is simple in construction, but for many years its numerous drawbacks have caused it to be much neglected, even in countries which have legalized it.

Disadvantages of the mercury-ohm standard are: The conducting material has a high temperature coefficient of resistance, which in conjunction with the high thermal resistivity of glass makes it difficult to measure the temperature of the mercury with sufficient exactness and limits the allowable test current through the mercury column to a small value. It is known now that mercury is not a simple substance, but a mixture of isotopes. (This is not a serious objection from the practical standpoint, because the particular mixture of isotopes of mercury found in nature seems to be very closely the same everywhere.) The mercury is liable to slight contamination from the metal electrodes immersed in it. Glass tubes cannot be made straight and of uniform bore, and the error arising from waviness of the bore, though of known sign, is of indeterminable magnitude. Terminal bulbs which are necessary to make connection to the ends of the mercury column introduce an uncertainty because as yet no method has been found for definitely calculating the terminal resistance with sufficient accuracy; this makes it necessary to adopt an empirically chosen size of end bulb. The wires which lead the current into the terminal bulbs must be small so as to minimize the conduction of heat to the mercury; they are therefore of relatively high resistance, which is a drawback in some methods of effecting electrical comparisons.

It may be of interest to summarize some of the other major reasons for the original adoption of the mercury ohm and its present obsolescence. The mercury ohm originally was proposed at a time when electrical workers were isolated. Existing means of communication were slow and imperfect, and hence each worker felt the need of preparing his own standards. Although the underlying absolute electrical units were recognized from the beginning of the B.A. committee's work, the crudities of apparatus and technique of absolute measurements resulted in such a scattering of values obtained, as to constitute an imperative reason for a physical standard of resistance reproducible from specifications.

The situation has altered greatly since the beginning of the present century. The day of the isolated worker, setting up his own standards, has passed, and now great national standardizing laboratories not only establish standards with an accuracy beyond the resources of most individual workers, but have a legal status which gives the stamp of authority to their certified values. By the exchange of standards, these national laboratories keep in touch with one another, thus securing a measure of international uniformity.

Absolute Measurements

It is beyond the scope of this article to give more than the briefest reference to absolute measurements. The spinning coil of the B.A. committee already has been mentioned. The Lorenz apparatus is an elementary dynamo in which a non-magnetic metallic disk is rotated within the magnetic field of two solenoids wound on non-magnetic cores and traversed by a steady direct current from an external source. The apparatus thus constitutes a sort of homopolar generator in which an e.m.f. is induced radially in the rotating disk. At a certain definite speed, this induced e.m.f. will just balance the IR drop between the potential terminals of a four-terminal resistance standard through which passes the steady current circulating in the solenoids. From the accurately determined speed of rotation, and from mechanical measurements of the dimensions of the disk and of the field coils, the resistance of the standard between its potential terminals can be calculated in terms of the c.g.s. absolute electromagnetic unit. The most outstanding Lorenz apparatus built thus far is that at the British National Physical Laboratory.

An absolute apparatus, simpler in some respects, is used at the German Reichsanstalt and at the United States Bureau of Standards. It employs single-layer solenoids wound upon accurately machined cylindrical forms of non-magnetic material such as marble. In terms of the fundamental units, the self-inductance of such a coil can be computed with high accuracy from measurements of its dimensions. The self-inductance also can be measured in terms of the international ohm and the second of time by means of a-c. methods, using currents of which the frequency is known accurately. From the two results may be derived the ratio of the international henry to the absolute henry (10^9 c.g.s. units of inductance). It may be shown that this

ratio, which is 1.00052 plus or minus a few units in the last place, is also the ratio of the international ohm to the absolute ohm. Results obtained by this a-c. method are in close agreement with those obtained with the Lorenz apparatus.

Legalized Standards Needed

It would be premature to attempt to set even an approximate date for the establishment of the absolute electrical units on a *legalized* basis, but there are urgent reasons for reaching this goal as soon as possible. Rapid development of electrical technology in recent years has imposed new and exacting demands for accuracy of measurement and permanency of standards. Nowhere is this demand more impressive than in some phases of the radio art where for example frequency measurements are carried out and standards of frequency have been developed to an accuracy so great (a few parts in ten million) as to threaten to expose the failings of even the most highly developed timekeepers used in observatories. The world-wide sweep of radio makes international uniformity of frequency standards an imperative necessity.

Electrical standards of various kinds, embodying errors known to exist in the present units, are being made and distributed more widely than ever. This is an added incentive toward legalization of absolute units, for the longer such action is deferred, the more costly and troublesome will be the necessary readjustment of the standards used in engineering and science when such legalization ultimately is accomplished.

International Standard of Electromotive Force

Although unremitting care must be exercised in their manufacture and handling, cadmium cells have proved to be convenient and reliable sources of standard e.m.f. Principal characteristics of these units and precautions to be observed in their use are pointed out in this article.

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THE INTERNATIONAL VOLT is defined in terms of the mercury ohm and the silver voltameter. This combination, in addition to being unsuitable for routine work, requires that an unchanging potential drop be maintained across the standard ohm which in turn demands that a source of constant e.m.f. be available to maintain a constant current through the voltameter. Such a source of constant e.m.f. when so used undergoes calibration and thus may become useful as a standard of e.m.f. without combination with the voltameter and the ohm. If such sources are to serve as primary standards, for convenience they should be reproducible.

In practise, galvanic cells provide serviceable standard sources of e.m.f., and are known as *standard cells* when they fulfil the necessary requirements. Two general types of construction are to be had, namely, the portable form in which the constituents are kept in place by a plug or septum of porous material, and the non-portable type without a septum, gravity holding the constituents in place. Generally the container is a glass vessel made of tubing in the form of an H.

In addition to this purely physical distinction in standard cells, there is a more fundamental difference between *normal* or *saturated* cells and *unsaturated* cells. The normal cell contains an excess of the salt of the electrolyte, and it is reproducible at all temperatures within its range. The unsaturated cell has an electrolyte saturated at some temperature below the customary range of room temperatures. Therefore, due to difficulties of technique, the unsaturated cell is not reproducible. However, it is constant in e.m.f. and has a lower temperature coefficient than does the normal cell. Temperature coefficient of the unsaturated cell can be taken as less than −0.00001 volt per deg. cent.; hence, though the normal or saturated cell makes the best primary standard, the best laboratory standard is the unsaturated cell calibrated against the normal cell, the latter in turn having a value based upon the ohm and the voltameter.

Weston Introduced Cadmium Cell in 1893

Although several different standard cell systems have been introduced, all except one now are of historic interest only. The specific system in general use today is that proposed by Dr. Edward Weston; its unsaturated form was patented by him in 1893, and consists of mercury-mercurous sulphate-aqueous solution of cadmium sulphate-cadmium amalgam. In his honor, the two types of this cell are known, respectively, as the normal Weston cell or the

Based upon "International Standard of Electromotive Force and Its Low-Temperature-Coefficient Form" (No. 31-121) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22–26, 1931.

saturated Weston cell, and as the unsaturated Weston cell or simply the Weston cell. These cells are known also as the cadmium cells, the terms cadmium cell and Weston cell being synonymous as applied to the composition of the system, but the latter requiring no further qualification to denote that it specifies an unsaturated element.

Materials used in cells require careful chemical treatment. Mercurous sulphate is particularly sensitive, but when mixed with finely divided mercury can be prepared by electrolysis; this is the best preparation found so far. Cadmium sulphate would seem to require more rigorous purification than it has received at the hands of many investigators in the past, more especially to eliminate salts of manganese. Mercury must be redistilled after washing in acid, and only the purest cadmium must be used.

Use of Standard Cells

Since current should not be drawn from standard cells when making comparisons against such units, only a null-point or compensation method should be used; some form of potentiometer provides this. ("A Simple Direct-Reading Potentiometer for Standard Cell Comparisons," Eppley & Gray, *Jl. Opt. Soc. Am.*, v. 6, 1922, No. 8, p. 859–64, and "An Improved Fuessher Type Potentiometer," Eppley & Gray, *Rev. Sci. Inst.*, v. 2, 1931, No. 4, p. 242–9.) Usually the entire e.m.f. of the cell used as standard is compared against the entire e.m.f. of the cell being checked; in this method the potential drop in the potentiometer acts as a transfer-standard. This drop must be kept constant, so that it is well to lag the storage cell (which furnishes the potentiometer current) with heat-insulating material to prevent changes in room temperature from causing fluctuations in the measuring current, or potential drop. For best results, accumulators should be kept on a stand above the floor in order to avoid drafts. With this precaution, and by shifting from standard to unknown several times with readjustment of the measuring current if necessary and the attainment of a new balance with the unknown, results can be obtained with a potentiometer of proper design that will be reproducible from day to day within 6 microvolts. Furthermore, this method has the convenience of being direct-reading.

One disadvantage of the method just described, though perhaps more theoretical than real, is that the standard and the unknown are not compared at the same instant. For measurements beyond criticism, therefore, it is best to oppose the unknown and the standard, reading the difference in e.m.f. on a potentiometer or by some other suitable means. This reduces to a minimum the effect of fluctuations in the measuring current, and makes use of only one or two dials of the potentiometer with a corresponding reduction in the number of corrections to be applied. This method is not direct-reading, however, and the sign of the residual must be watched carefully. Whatever method be used, the measuring current must be made such that it will have come to a steady state. Careful attention should be given also to shielding the installation against stray leakage currents.

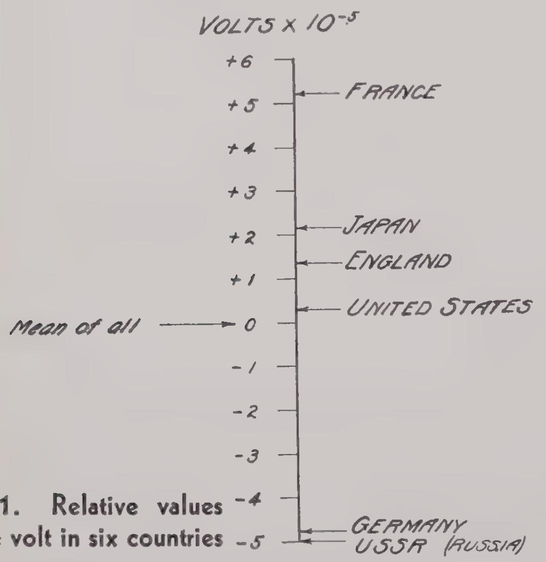

Fig. 1. Relative values of the volt in six countries

By Vinal, *Trans.* Am. Electrochemical Soc., 54, 251 (1928) Fig. 1

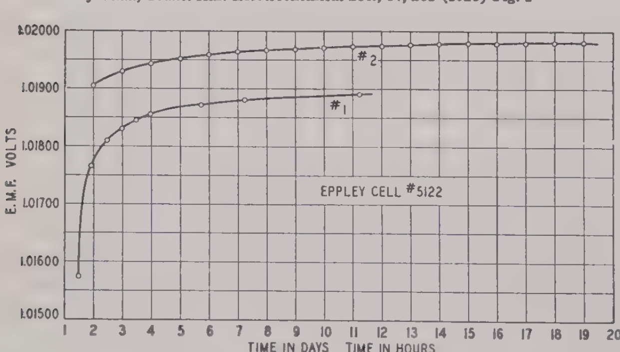

Fig. 2. Voltage recovery of an unsaturated cadmium cell after 30-min. short circuit

Curve 1—voltage vs. hours for first day
Curve 2—voltage vs. days from second day
Volts before short circuit—1.019875
Volts after 36 days' recovery—1.019800

Voltage of the Weston Cell

Looking forward to its ultimate use as the international standard of e.m.f. in place of the Clark cell, the London International Electrical Congress in 1908 adopted specifications for the Weston normal cell provisionally fixing its e.m.f. at 1.0184 international volts at 20 deg. cent. On January 1, 1911, however, after much experimentation by the International Technical Committee (composed of delegates from the national standardizing laboratories of Great Britain, France, Germany, and the United States) the e.m.f. of the normal cadmium cell was adopted by the Bureau of Standards as 1.01830 volts at 20 deg. cent. for the United States. During the interval 1924 to 1928, the reference cell at the Bureau of Standards has agreed to within 8 microvolts with the mean of the primary reference group (a group of 36 cells left at the Bureau by delegates of the International Technical Committee). The value of e.m.f. at the Bureau of Standards is about 3 microvolts higher than the mean of the values of the cells maintained in France, Japan, England, the United States, Germany, and the U.S.S.R. (See Fig. 1.)

All cadmium cells show a temperature hysteresis of e.m.f.; although this can be made very small, it still exists. Hence cells should not be subjected to sudden changes of temperature. Cooling from 30 to 25 deg. cent. in 70 min. caused a divergence of 0.02 per cent in one group and 0.027 per cent in two groups of cells respectively, the basic value being the mean of the e.m.f.'s obtained before the cells were run through a temperature cycle from 15 to 50 deg. cent. and back to 25 deg. cent. as above.

Unsaturated or Weston cells show a drop in e.m.f. of about 0.003 per cent per annum, so that for an accuracy of 0.01 per cent they should be recertified at least once every two years. This drop is explained best by the diffusion of mercurous ions to the amalgam face where it is discharged, mercury depositing out and cadmium going into solution; this increases the cadmium concentration of the electrolyte with a resultant drop in e.m.f. When the concentration of the normal or saturated cell is reached, the e.m.f. should remain constant at 1.01830 volts at 20 deg. cent., but an increase in the temperature coefficient will have been brought about. Some cells drop in e.m.f. more rapidly than 0.003 per cent per annum, and do not come to a constant e.m.f. when the value of the saturated cell is reached; this is due to the systems not having been set up properly. Such cells usually show marked hysteresis effects when subjected to temperature changes, and should be discarded accordingly.

Care and Handling of Cells

Cells should not be short-circuited as this is likely to upset permanently the original equilibrium of the electrolyte. In a special test three cells short-circuited for ten minutes required seven hours to return to within 0.02 per cent of their original values. (See Fig. 2.) Furthermore, it is best never to draw more than 0.0001 ampere from a cell even if the circuit is closed momentarily only.

Cells should not be exposed to heat even as much as that radiating from an electric light bulb. Such heating, when greater on one side of a cell than on the other, has given rise in unmounted cells to variations of from 0.01 per cent to 0.02 per cent, even though the lamp was rated at only 25 watts and was 15 in. away from one leg of cells. (The exposure was for five minutes only.) Similar effects have been observed in cells mounted in molded cases. Drafts as well as heating due to handling also should be avoided.

Shaking seems to have no effect upon properly made portable cells, provided it is neither too vigorous nor too long. However, after a cell has been shipped, it is better, as a safety measure, to let it stand for two or three days at least before placing reliance upon it.

If an accuracy of at least 0.02 per cent is wished, cells should not be used at temperatures below 15 deg. cent., although even freezing in some cases has seemed to have had no permanently injurious effect. Recovery from cooling, say to about 12 deg. cent., is rapid requiring only an hour or so at the most to restore the proper e.m.f.

This brief discussion may have raised doubts as to the reliability of the cadmium cell as a standard of e.m.f. It is true that the cell is by no means foolproof, but few precision devices are. Ceaseless care must be given to its manufacture, and a thorough knowledge of its chemistry gained in order to insure the maximum of constancy and agreement. Nevertheless, there are few if any other electrical measurements in which so high a precision (0.01 per cent) can be secured with so few precautions as in the determination of e.m.f. by means of a standard cell and some form of potentiometer.

Recent Developments in Magnetic Units

To overcome confusion in the use of electromagnetic units, the International Electrotechnical Commission through its subcommittee on electric and magnetic magnitudes and units has been working for several years toward standardization in definition and nomenclature. In this article, recent actions in that direction are discussed and a brief summary of earlier contingent actions is given.

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Examination of the technical literature of the magnetic circuit during the past 30 years shows much ambiguity and misunderstanding among writers in all parts of the world, as to the definition and meaning of the magnitudes of units in general use. In particular, the name "gauss" has been used by some writers for the c.g.s. unit of magnetizing force H, by others for the c.g.s. unit of magnetic flux density B, and by still others for both H and B indiscriminately. Moreover, the important and much used quantity permeability μ, admittedly defined as the ratio B/H, has been regarded by some as having physical dimensions, and by others as having zero dimensions or as being a mere numeric. This confusion

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of definitions apparently has pervaded the literature of all countries. It gives rise to much misunderstanding and perplexity in the study of either basic or applied magnetism. These differences of thought and expression are found in text-books both of physics and of electrical engineering. It is this confusion brought about in electrotechnical literature that is the main source of complaint.

From a practical standpoint, the underlying philosophy of the electromagnetic field is of lesser importance than the arithmetical meaning of the formulas necessarily used in engineering; hence the urgency of international agreement upon the definitions involved, even though it may be admitted that these rest upon mere conventions. This brief and unofficial account of efforts to arrive at such agreement may be of service to readers of electrotechnical journals who may not have been fully informed of what the International Electrotechnical Commission already has been able to accomplish in this direction. It is hoped also that the article may be of value even to those who may read the official minutes, but who are not fully acquainted with the subject's history.

Summary of Earlier Actions in Magnetic Unitology

At the I.E.C. plenary meeting of 1927, in Bellagio, a proposal was introduced to adopt a unit of magnetic flux Φ in the practical or volt-ampere-ohm series of units. After discussion, this was referred for consideration and report to a special subcommittee of seven members representing as many different national committees. This subcommittee was unable to reach agreement, but recommended that the questions be studied by all the national committees and be brought up for discussion at the next plenary meeting of the I.E.C., set for 1930 in Scandinavia. (See "Magnetic Circuit Units," A. E. Kennelly, A.I.E.E. Trans., v. 49, 1930, p. 486–93.)

Accordingly, the subcommittee on magnetic units convened at the 1930 meeting in Scandinavia. Its membership was increased to include twelve countries, and its name was changed to Section B of I.E.C. Advisory Committee No. 1 (nomenclature) on Electric and Magnetic Magnitudes and Units, hereafter referred to as the E.M.M.U. subcommittee.

During June and July 1930 the E.M.M.U. subcommittee held several meetings at Stockholm. Its first action was to agree unanimously on the convention that inasmuch as flux density B and magnetizing force H, in free space have different physical dimensions; their ratio μ_0 (space permeability) is a dimensional quantity and not a mere numeric unit. Also it was agreed unanimously that μ/μ_0, the ratio of the absolute permeability of a magnetic substance to space permeability, should be called its relative permeability and should be taken as a pure numeric. (See "Magnetic Circuit Units Adopted by I.E.C.," A. E. Kennelly, Electrical Engineering, v. 50, 1931, p. 133.)

After disposing of this permeability question, the E.M.M.U. subcommittee next adopted the names for four c.g.s. magnetic units, either unanimously or by a large majority. These are given in Table I.

Table I—C. G. S. Magnetic Units Adopted at Oslo in 1930 and Reendorsed at London in 1931

Unit	Symbol	Name
Magnetomotive force	$\mathcal{F}$	gilbert
Magnetizing force	H†	oersted
Magnetic flux	Φ	*maxwell
Flux density	B†	gauss

*The name "maxwell" had been adopted at Paris in 1900, with the same meaning.
†Script symbols $\mathcal{B}$ and $\mathcal{H}$ sometimes are used, but because of their convenience italic capitals as shown above are recommended.

The name "oersted" had been used in America for the c.g.s. unit of reluctance $\mathcal{R}$ but had not been adopted internationally. It was transferred to the unit of H, on the proposal of the Danish committee, partly because Oersted's discovery of 1820 related to H and not to $\mathcal{R}$, and partly to indicate that "gauss" was considered inapplicable to H, after having been assigned to B because of their accepted difference of dimensions.

In addition to the foregoing, the E.M.M.U. subcommittee adopted at Stockholm the practical unit of magnetic flux Φ with the value of 10^8 maxwells, and with the name *pramaxwell*. It was agreed also to adopt the prefix "pra" as applicable to deriving practical units from corresponding c.g.s. units. Other actions taken concerned reactive power and power factors in a.-c. circuits. These have not been subjected to serious criticism since the Stockholm meeting and already have been adopted, at least to some extent, in various countries. They all are duly set forth in I.E.C. *document R.M.77* (French and English texts).

All of the actions mentioned were reported and unanimously approved at the I.E.C. plenary meeting in Oslo on July 9, 1930.

Events Occurring Between 1930 and 1931

Actions taken in 1930 at Oslo regarding magnetic units gave rise to a great deal of discussion in electrotechnical journals throughout the world, and particularly in the pages of the *Revue Générale de l'Electricité*. Criticism centered mainly about two points: That the names of savants should not have been given to units inthe c.g.s. system, but should have been reserved for units in the practical system; and that the name "gauss" should not have been given to the unit of flux density B, but to that of magnetizing force H, in conformity with established usage in magnetic observatories.

Regarding the first objection, it has been pointed out that although up to and including the year 1893, the date of the Chicago international congress, names of savants were assigned exclusively to practical units, yet owing to the decisions of the Chicago congress that magnetic units should be kept within the c.g.s. system, the names "gauss" and "maxwell" were given purposely at the Paris congress in 1900, to c.g.s. magnetic units. Therefore, the I.E.C. meeting at Oslo merely followed the actions taken at Paris. It has been pointed out also that the earth's magnetic field has been recorded for many years in gauss or gammas of 10^{-5} gauss, yet this field always is measured in air, a feebly magnetizable medium; what actually is determined is a terrestrial flux density B in

the air. Consequently, although from a practical standpoint the numerical difference between H and B in air may be insignificant, yet no error in principle is created by speaking of the earth's field in gammas referring to B.

In view of the differences of opinion elicited by the publication of the decisions reached at Oslo, arrangements were made and announced early in 1931 to all the national committees, for holding a meeting of the E.M.M.U. subcommittee at London in September 1931.

New Committee Established

In July 1931 the International Union of Pure and Applied Physics met at Brussels and for the first time established an international committee on "Symbols, Units, and Nomenclature" (S.U.N.). This committee elected as its chairman, Sir Richard Glazebrook, and as secretary, Dr. E. Griffiths. Since electrotechnical units fall within the scope of the S.U.N. committee, the members of that committee were invited to attend and participate in the London meeting of the E.M.M.U. subcommittee on September 18, 1931. The chairman and secretary of the S.U.N. committee were able to accept and took part in the meeting, as also the general secretary of the International Physical Union, Prof. H. A. Abraham.

Actions at the London Meeting in 1931

National committees of ten countries were represented at the opening E.M.M.U. subcommittee meeting in London on September 18, 1931; countries represented were: Denmark, France, Germany, Great Britain, Holland, Italy, Norway, Poland, Sweden, and U.S.A. Proposals considered and actions taken are reviewed briefly in the following paragraphs.

1. A proposal "that the c.g.s. magnetic units and their accepted names as fixed at the Oslo plenary meeting should remain undisturbed." This proposal was voted unanimously, two countries, however, abstaining (Holland and Italy).

2. A proposal relating to a series of practical magnetic units, based upon the volt-second or "pra-" system as adopted at the Stockholm meeting, with the ampere-turn as unit of m.m.f. After a lengthy discussion, during which considerable difference of opinion was revealed, it was unanimously voted to defer action on these practical units until the national committees should have had further opportunity for investigation; however, on the particular question of a practical unit of magnetomotive force $\mathfrak{F}$, and whether a coil of N turns, carrying a steady current of I amperes, should be taken as $\mathfrak{F} = 4\pi NI$ units or merely $\mathfrak{F} = NI$, a vote was called for, on the proposition that it should be the former. Three countries were in favor of the proposal (France, Holland, and Italy) while four voted against it (Germany, Great Britain, Sweden, and U.S.A.); two countries (Norway and Poland) abstained from voting. It is evident that there is much difference of international opinion over this important question.

3. Conventional interpretation of reactive power in unspecified a-c. right-angled power diagrams. The question considered was whether $+ j$ *vars* should be taken as signifying inductively reactive power or the reverse when the basis of the diagram is not specified. It was voted unanimously that a convention be adopted, but that decision as to direction be deferred until a new and definite American recommendation should be presented. Some difference of opinion had been raised as to whether the particular direction recommended ($+ jP_r$ for inductively reactive power) was the more advantageous choice.

4. Proposed international adoption of the prefixes "ab" and "stat" applied to a practical unit, for the designation of a corresponding unit in the c.g.s. magnetic or in the c.g.s. electrostatic system, respectively. These prefixes have been and are in use to some extent in America, but never have been adopted internationally. For lack of support to the proposal, no action was taken.

At the conclusion of the foregoing considerations it was unanimously voted to ask the central I.E.C. office to invite the cooperation of the International Physical Union to participate in the formation of a joint committee to consider the question of the electrotechnical units under discussion. It was the general hope that there might be close cooperation in the future between the two organizations on all questions in which physics and electrotechnics jointly are involved.

Results of the London Meeting of 1931

Consequences of the London meeting of the E.M.M.U. subcommittee may be of far-reaching international importance in electrotechnics if they serve, as apparently they should, to terminate the confusion in the use of the c.g.s. magnetic units which has existed in the literature of electromagnetic engineering throughout the world for at least 30 years. The series of names and definitions for these units adopted in 1930 during the plenary meeting at Oslo has been discussed openly in many countries for more than a year, and these were reendorsed without opposition at the London meeting. It is to be hoped therefore that the units as adopted will come into general electrotechnical use.

There remain at least four c.g.s. magnetic units that as yet have received no names (permeance, permeability, reluctance, and reluctivity); but the four units to which definitions and names have been given (see Table I) probably are sufficient for present practical purposes. These are based upon the convention that space permeability is more than a mere number. There remain a certain minority of both physicists and engineers who disagree with that convention; but after so many years of ambiguous reading and writing it would be strange indeed if an immediate unanimity on this difficult question could be obtained in every country. It can only be hoped that a harmonious procedure through international convention will be secured, and this the recent London meeting has endorsed.

From a philosophical point of view, it is curious that the London endorsement of the I.E.C. Oslo action on magnetic units and their underlying convention should have been almost coincident with the London Faraday celebration of 1931. It is admitted generally that Faraday's researches made magnetic flux in space the salient phenomenon in magnetics, whereas the magnetic pole or quantity of magnetism on a polar surface previously had been the dominating concept. It has been suggested that the modern change in underlying convention reflected in the I.E.C. actions may be attributable to the change in views resulting from Faraday's work.

As for the series of practical magnetic units introduced by the adoption at Oslo of the *pramaxwell*, the whole question is to be discussed further by the national committees of the I.E.C. in cooperation, it is to be hoped, with the International Physical Union before proceeding further in that direction. For the present, we may remain well content to work with the c.g.s. system.

News
Of Institute and Related Activities

Summer Convention Offers Attractive Program

FOR THE 48th annual summer convention of the A.I.E.E. to be held at Cleveland, Ohio, June 20–24, 1932, the Cleveland national convention committee has planned a program of entertainment, inspection trips, and recreation, supplementing the excellent technical sessions, all of which should cause this convention to be attractive as a vacation as well as of benefit professionally. Convention headquarters will be at the Hotel Cleveland, located on the Public Square of the city.

Technical Sessions

Many papers covering a wide variety of interesting subjects in the field of electrical engineering will be presented in nine technical sessions scheduled during the week of the convention. Two of the sessions comprise well arranged symposiums, one on the combined aspects of reliability and economy in the operation of large electric systems; the other on conductor vibration. The former symposium will represent system operating practise in four different localities: Philadelphia, Detroit, Boston, and Chicago. The latter will present valuable data as a result of both laboratory and field investigations.

Besides these symposiums four other sessions, namely, electrical machinery, electrochemistry-electrometallurgy and research, protective devices, and automatic stations, will afford much of unusual interest in the fields of design, theory, research, and operation. The session devoted to communication should have a broad appeal because of the general interest in the subjects to be presented, and in addition, there will be interesting demonstrations. Still another session on selected topics will offer interesting papers, some of the subjects of which have originated in Cleveland and its environs. One of these relates to the method of wiring buildings as an essential to good illumination. Several others pertain to both synchronous motor and induction motor applications and performance.

For the first time in recent years a session will be devoted entirely to education. Even interests outside of the specific confines of the Institute are being attracted to this session which will start with a paper by Dr. W. E. Wickenden, president of Case School of Applied Science. In order to permit all to participate in this session, the three parallel meetings which occur in the morning will not begin until the conclusion of Doctor Wickenden's address.

Entertainment Features

The opening day will stage the beginning of the annual golf tournament at the beautiful Canterbury Club course, and the beginning of the tennis tournament at the University Club courts. Qualifying rounds for the golf tournament must be played Monday. Those not participating in the tournament may play throughout the week at the Canterbury Club, the Mayfield Country Club, and other private courses.

The president's reception followed by dancing will take place Monday evening at the Hotel Cleveland. Tentative plans have been made for a possible boat trip on Tuesday evening.

An innovation this year will be the substitution of social afternoon and evening for men, women, and children, instead of the usual formal banquet. The entertainment is to be staged on the beautiful grounds of Nela Park, with various field events, dinner and dancing included.

Full details of the generous entertainment program and the several novel features planned for the convention will be given in a program folder being prepared by the Cleveland convention committee, and soon to be mailed by that committee.

Ladies' Entertainment

For the ladies a visit to the Art Museum on University Circle, a drive through the residential sections, and an afternoon tea at Shaker Tavern are planned for Monday. Golf, luncheon, and bridge at the Canterbury Club will be available for them on Tuesday, and among the trips arranged for their entertainment on the following days are visits to a model furnished home built in the Builders' Exchange Building, the Terminal Tower, a radio broadcasting studio and a large modern bakery as well as a drive through the beautiful Metropolitan Park system of the West Side.

Inspection Trips

Inspection trips for all interested include the entire route of the recent electrification of the Union Terminal, Avon generating station, d-c. and a-c. substations, the new Ohio Bell Telephone building and exchange facilities, strip mills of the Otis Steel Company representing latest developments in electrification of such mills, and a trip to Akron to visit the many interesting places in that city.

In connection with the previously mentioned entertainment at Nela Park, inspection trips will be conducted during the afternoon. On Friday the entire con-

Canterbury Golf Club near Cleveland, Ohio, will be the scene of many hard-fought battles during the rapidly approaching summer convention of the Institute

vention will be conducted on a drive through the East Side to observe an abundance of attractive features.

REGISTRATION

There is no registration fee for attendance at the convention. Each member should register in advance by using the post-card to be mailed for that purpose, thus assisting the necessary advance preparation. Registration for the various sports also should be made on the card.

In connection with the entertainment features of the convention there will be a charge of $5 per person, payable upon registration. This fee covers all features except greens fees, and includes the special feature on Thursday which will replace the usual formal banquet.

All hotels noted in the accompanying table are within a five-minute walk of convention headquarters. Reservations for hotel accommodations should be made by writing directly to the hotel preferred.

Reduced railroad rates on the certificate plan will be available for those attending the meeting, and summer tourist fares at a lower rate will be in effect from certain western states.

Program

All technical sessions and the opening of the convention will be held at the Hotel Cleveland. All events are scheduled in *Eastern Standard Time*. Abstracts of papers to be presented at the sessions are scheduled for publication in the June 1932, issue of ELECTRICAL ENGINEERING.

Hotel	Rooms	Single	Double
Cleveland (headquarters)	1,000	$3.00–$ 8.00	$4.50–$10.00
Hollenden	1,050	3.00– 5.00	5.00– 9.00
Statler	1,300	3.50– 10.00	5.50– 10.00
Winton	525	2.50– 4.00	4.00– 5.50
Allerton	550	1.50– 3.00	2.50– 4.00
Auditorium	300	2.00– 3.00	3.50– 5.00
Olmstead	300	2.00– 3.00	4.00– 6.00

Hotel rates are for rooms with bath, European plan. Reservations for accommodations should be made by writing directly to the hotel preferred.

Nela Park, in Cleveland, where a novel entertainment feature will be staged this year during the afternoon and evening of Thursday, June 23

Monday, June 20

9:00 a.m.—Registration

10:00 a.m.—Opening Session

Annual business meeting of the Institute

Annual report of the board of directors (in abstract)

Report of tellers' committee on election of officers; introduction of and response from president-elect.

Presentation of prizes for papers

Lamme Medal presentation

President's address, by C. E. Skinner

2:00 p.m.—Conference of Officers, Delegates, and Members

Inspection trips

Evening—President's Reception

Tuesday, June 21

9:30 a.m.—Special Session

*ADDRESS ON EDUCATION—W. E. Wickenden, president, Case School of Applied Science.

10:15 a.m.—(A) Education

*THE ENGINEERING SUBJECTS, ELECTRICAL AND COGNATE IN THE FOUR-YEAR COLLEGE PROGRAM OF ELECTRICAL ENGINEERING, A. H. Lovell, University of Michigan

EDUCATIONAL ASPECTS OF ENGINEERING AND MANAGEMENT, R. E. Doherty, Yale University

†*ADULT TECHNICAL EDUCATION IN METROPOLITAN AREAS, O. W. Eshbach, American Telephone & Telegraph Co.

10:15 a.m.—(B) Symposium on Combined Aspects of Reliability and Economy in the Operation of Large Electric Systems

PHILADELPHIA ELECTRIC COMPANY'S SYSTEM, J. W. Anderson and Herbert Astrada, Philadelphia Electric Co.

THE DETROIT EDISON COMPANY'S SYSTEM, A. P. Fugill, Detroit Edison Co.

THE EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON'S SYSTEM, R. E. Dillon, The Edison Electric Illuminating Company of Boston

CHICAGO DISTRICT, L. L. Perry and F. V. Smith, Sargent and Lundy, Inc.

Notice of Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in the Hotel Cleveland, Cleveland, Ohio, at 10 a.m. on Monday, June 20, 1932. This will constitute one session of the annual summer convention, which is to be held this year in Cleveland, June 20–24.

At this meeting the annual report of the board of directors and the report of the committee of tellers concerning the ballots cast for the recent election of officers will be presented.

Such other business, if any, as properly may come before an annual business meeting may be considered.

(Signed) H. H. HENLINE
Assistant National Secretary

10:15 a.m.—(C) Electrochemistry—Electrometallurgy and Research

*ELECTRICAL EQUIPMENT FOR PRECIPITATION SERVICE, H. Speight, Westinghouse Electric & Mfg. Co.

*OXIDE COATINGS ON ALUMINUM, J. D. Edwards, Martin Tosterud and H. K. Work, Aluminum Company of America

*CALCULATION OF INDUCTANCE AND CURRENT DISTRIBUTION IN LOW VOLTAGE CONNECTIONS TO ELECTRIC FURNACES, C. C. Levy, Westinghouse Electric & Mfg. Co.

*NEW APPLICATIONS OF NON-LINEAR CIRCUITS TO RELAY AND CONTROL PROBLEMS, C. G. Suits, General Electric Co.

2:00 p.m.—Conference of Officers, Delegates, and Members (cont'd)

Inspection Trips

Wednesday, June 22

9:30 a.m.—(D) Electrical Machinery

THE COORDINATION OF TRANSFORMER INSULATION WITH LINE INSULATION, V. M. Montsinger, General Electric Co., and W. M. Dann, Westinghouse Electric & Mfg. Co.

*COORDINATION OF DISTRIBUTION TRANSFORMERS, E. D. Treanor and W. H. Cooney, General Electric Co.

*LOAD RATIO CONTROL CIRCUITS, L. F. Blume, General Electric Co.

INFLUENCE OF BRUSH CONTACT DROP ON COMMUTATION, L. R. Ludwig and R. M. Baker, Westinghouse Electric & Mfg. Co.

*SINGLE-PHASE SHORT-CIRCUIT TORQUES OF SYNCHRONOUS MACHINES, C. A. Nickle and M. L. Henderson, General Electric Co., and C. A. Pierce, Worcester Polytechnic Institute

†TRANSIENT ANALYSIS OF A-C. MACHINERY II, EXTENSION TO SALIENT-POLE MACHINES, Yu H. Ku, University of Chekiang

9:30 a.m.—(E) Communication

*WIRE COMMUNICATION AIDS TO AIR TRANSPORTATION, H. H. Nance, American Telephone & Telegraph Co.

*CHARACTERISTICS OF ELECTROMAGNETIC RADIATION FROM AIRCRAFT IN FLIGHT, J. C. Coe and T. C. Rives, Signal Corps, War Department

*VERTICAL SOUND RECORDS, H. A. Frederick and H. C. Harrison, Bell Telephone Laboratories, Inc.

2:00 p.m.—Trip to Akron

Thursday, June 23

9:30 a.m.—(F) Selected Subjects and Technical Committee Reports

*Adequate Wiring of Buildings, An Essential for Good Illumination, G. H. Stickney and Walter Sturrock, General Electric Co.

*Induction Motor Versatility—The Nature of Its Applications, E. W. Henderson, The Reliance Electric and Engineering Co.

Dynamic Braking of Synchronous Machines, E. E. Kilbourne and I. A. Terry, General Electric Co.

9:30 a.m.—(G) Protective Devices

Application of High Speed Relays, G. W. Gerell, Union Electric Light and Power Co.

A High Speed Reactance Relay, A. R. van C. Warrington, General Electric Co.

†Relay Operation From Bushing Potential Devices, P. O. Langguth and V. B. Jones, Westinghouse Electric & Mfg. Co.

†Operation of Relays From Carrier-Current Coupling Capacitors and Capacitance Transformer Bushings, J. E. Clem and R. M. Cordray, General Electric Co.

The Boric Acid Fuse, A. P. Strom and H. L. Rawlins, Westinghouse Electric & Mfg. Co.

Afternoon and Evening—Entertainment at Nela Park

Friday, June 24

9:30 a.m.—(H) Automatic Stations

*Torque Balance Telemetering, A. J. Johnston, General Electric Co.

*Developments in Two-Wire Supervisory Systems, J. H. Oliver, General Electric Co.

*Operating Experience With Supervisory Control on the Reading-Philadelphia Suburban Electrification, J. E. Pastoret, Reading Co.

*The Application and Performance of Automatic Equipment at Stations and Substations on The American Gas and Electric Company's System, Philip Sporn, Basil Lanphier and H. E. Turner, American Gas and Electric Co.

9:30 a.m.—(I) Symposium on Conductor Vibration

Stress-Strain Studies of Transmission Line Conductors, G. W. Stickley, Aluminum Research Laboratories

Vibration and Fatigue in Electrical Conductors, A. E. Davison, J. A. Inglis, and V. M. Martinoff, Hydro-Electric Power Commission of Ontario

*Vibration of Overhead Transmission Lines, R. A. Monroe and R. L. Templin, Aluminum Company of America

*Transmission Line Vibration Due to Sleet. J. P. Den Hartog, Westinghouse Electric & Mfg. Co.

* These papers are under consideration for presentation at the summer convention, but up to date of going to press have not been officially placed upon the program.

† These papers will not be published in the Transactions or in advance form by the Institute but copies may be made available by the respective authors.

Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, ten minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually five minutes are allowed each discussor. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a five-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discussor is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before July 8, 1932.

Summarized Review of Some Milwaukee Meeting Discussions

Principal discussions of Milwaukee District meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in Electrical Engineering for March 1932, p. 188–92. Additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the Transactions.

Toll Switching Plan for Wisconsin

In connection with this subject E. W. Neubauer (Chicago, Ill.) discussed several features in effect under the toll switching plan in Illinois. He explained that one of the important results of the application of the toll switching plan is the improved toll service to small communities located somewhat away from the larger cities.

Glen Ireland (New York, N. Y.) discussed the general toll switching plan as a whole which covers the entire United States and eastern Canada. Only a few per cent of the circuit groups required to complete the routing arrangements of the general toll switching plan within the Bell System remain to be placed, and these represent less than 1 per cent of the circuit miles now in service. He referred also to the excellent progress that has been made in providing terminal repeater-switching pad arrangements at the more important switching centers throughout the country.

R. C. Siegel (Milwaukee, Wis.) also discussed this subject and cited advantages of the toll switching plan. He explained that limiting switching to fewer toll centers results in the concentration of larger numbers of toll circuits on a smaller number of main routes and the concentration of equipment in fewer central offices. Plans in Wisconsin within the next few years and ultimate planning also were discussed briefly.

Police Teletypewriter Communication

E. W. Neubauer (Chicago, Ill.) discussed this subject and referred to the various types of systems in use. The particular telegraph line system used for each link depends largely upon the length of the circuit and the type of telephone wires in use between the terminals. Maintenance methods for these police systems were explained and the importance of continuity of service at all times emphasized.

J. O. Carr (Park Ridge, Ill.) cited the many advantages from the use of this system by comparison with the older method of broadcasting and rebroadcasting telephone messages which permitted human error to enter into the problem and required a longer period of time on the receiving end of the system.

Weather Resistant Insulation for Line Wires

C. D. Brown (Milwaukee, Wis.) stated that his experience with the use of tree wire indicated that its outer covering had in many cases the same deficiencies with respect to impregnating compound as was brought out in the paper regarding weatherproof insulation. He inquired if investigation had been made of the properties of the weather resistant covering for tree wire, and if so, what were the results?

James H. Foote (Jackson, Mich.) also discussed this subject and it is his belief that seven years' life of weatherproofing on overhead wire would seem to be abnormally short. He cited a case where triple braid weatherproof had been in service eighteen years without showing any appreciable amount of raggedness or deterioration easily visible from the ground.

Waukegan Station

A. H. Lovell (Ann Arbor, Mich.) believed that to one not familiar with Chicago and its western surroundings, the choice of only 25,000-kw. units in 1923 and 65,000-kw. units in 1930 was puzzling. The authors were asked to discuss this reference to the size of the load in Chicago at those times.

W. S. Monroe (Chicago, Ill.) brought out that the history of this power station represented in a large measure the development of the power station industry in the Chicago district so far as steam pressure and steam temperature are concerned and the change of boiler furnaces from chain grate stoker to pulverized coal. He also explained that the last three units installed, numbers 3, 4, and 5, were each the largest single shaft units available at the time they were ordered.

115,000-Kw. Turbo-Alternator

S. H. Mortensen (West Allis, Wis.) discussed several of the design features of this generator which brought about a reduction of vibrations, stray fields, heating, etc. The advantages of substituting non-magnetic for magnetic coil supporting rings on the leakage fields and stray losses of a 2,500-kva., 3,600-r.p.m. generator were shown with curves.

One of the many points of interest discussed by C. J. Fechheimer (Milwaukee, Wis.) was the possible influence of the foundation of this generator, on its critical speed. He believes that in all probability the running speed is above the first critical speed and that it is important to remember that the influence of the foundation might lower the critical speed, and then there would be danger of encountering a higher critical speed near the running speed.

Philip Sporn (New York, N. Y.) inquired whether the use of hydrogen was given consideration in connection with the design. He believes that in addition to the improved performance of an 18-kv. winding possibly hydrogen would have raised the efficiency to a figure as high as 99 per cent and increased the rating by well over 1,000 kw. which would have justified considerable extra expenditure.

Mercury Rectifiers for A-C. Railways

In connection with the use of rectifiers instead of commutators L. R. Ludwig (East Pittsburgh, Pa.) considers the rectifier as a unidirectional switch whereas the commutator and brush he pointed out would pass current in either direction. Also the rectifier for practical reasons must have a comparatively small number of anodes or segments, whereas the commutator usually has many. Therefore, the utilization of the windings on the motor it is believed would not be nearly so good as if a commutator were used.

R. E. Hellmund (East Pittsburgh, Pa.) discussed the scheme proposed in this paper and pointed out that while considerable progress has been made in the development of rectifiers and similar electronic devices, however, perhaps even greater advances have been made in the design of single-phase motors. It is believed that their relative position today is about the same as in the early days and that present rectifier arrangements cannot compete economically with single phase commutator motors.

E. F. W. Alexanderson (Schenectady, N. Y.) is of the opinion that this development will lead to a practical solution because progress of the vacuum tube technique is rapidly leading to new and superior forms which in their turn make possible improved methods of correlating the power system, the vacuum tube, and the motor.

R. G. McCurdy (New York, N. Y.) discussed the probable inductive effects that would result from the use of the controlled grid mercury arc rectifier which may be expected to complicate the problems of coordination between single-phase a-c. railways and telephone circuits.

H. M. Trueblood (New York, N. Y.) in connection with this subject analyzed several factors and general observations based upon a comparison of the use of single-phase 25-cycle and 60-cycle energy upon the contact wire of an electrified railway using the running rails for return.

Mercury Rectifiers Versus Rotary Converters

D. C. West (East Pittsburgh, Pa.) emphasized the statements in the paper regarding the importance of service reliability. He also pointed out that within the past few years, the results of many years of development effort have brought the rectifier substation to the point where its existence is thoroughly justified throughout the field of d-c. railway power supply.

W. E. Gutzwiller (Milwaukee, Wis.) presented data which showed that the operating costs and service failures of the rectifiers mentioned in this paper were rather high in comparison with similar, but more modern, stations.

A 60-Cycle Transmission System

C. L. Fortescue (East Pittsburgh, Pa.) discussed the protective features of the line of the Milwaukee Electric Railway and Light Company described in the paper. He believes the spacing and height of the ground wires above the line wires should produce good shielding effect. Also as a large part of the line follows the railroad right-of-way, good grounding should be obtained and with the liberal tower clearances, a good record against lightning should be obtained with this line.

Insulator Sparkover

C. L. Fortescue (East Pittsburgh, Pa.) also discussed this subject and is of the belief that these papers cover research producing data which has been greatly needed by the industry; namely, the effect of humidity upon the 60-cycle flashover of different types of insulating structures.

In regard to this subject, A. O. Austin (Barberton, Ohio) pointed out that where humidity is high it is very important in making the tests that insulators be at room temperature, as otherwise large discrepancies may arise.

Philip Sporn (New York, N. Y.) referred to previous discrepancies in 60-cycle flashover of insulators as given by different manufacturers. Subsequent work of the lightning and insulator subcommittee showed that this was due largely to the different humidity conditions under which tests were made. Mr. Sporn believes that this paper definitely confirms the point and shows how consistently the results appear when plotted against relative humidity.

A Limiting Gap for Station Apparatus

C. L. Fortescue (East Pittsburgh, Pa.) complimented the author on the good work which he had done, especially in pointing out the necessity of coordinating insulation for positive as well as negative surges.

W. L. Lloyd, Jr. (Pittsfield, Mass.) does not agree with conclusions 1 and 3 giving the requirements which an ideal gap should have and its use in the station; he believes also that a great many tests would be necessary before one could be certain that conclusion 2 was justified. It was felt that the value of the paper might possibly have been enhanced if the measured test points of the curves had been given.

J. T. Lusignan (Mansfield, Ohio) analyzed the two principles involved in connection with the control type of limiting gap which provides for a wide variation of electrostatic field in order to secure practically any sparkover characteristic desired. Reference was made to several simple gap arrangements to illustrate the effect of uniformity of voltage gradient across the gap upon time lag of the gap; also to illustrate the effect of an unsymmetrical electrostatic field upon the polarity at which a gap will have a lower breakdown voltage.

J. J. Torok (East Pittsburgh, Pa.) emphasized the importance of the following points in the paper: first, the differences between the positive and negative flashover characteristics of various gaps and their importance in coordination; second, the relations of flashover between waves of various durations and the volt-time curve obtained by a flat-topped wave.

J. F. H. Douglas (Milwaukee, Wis.) discussed this paper and he believes that the different behavior of points and spherical electrodes with positive and negative electrification were clearly shown to be in accord with the electrostatic field theory, and were verified amply by experimental tests. He thought that future work might well be directed toward some of the details which are not yet fully explained.

Diameter and Spacing of Insulators

C. L. Fortescue (East Pittsburgh, Pa.) in his discussion of this subject emphasized that there was nothing untried in the type of insulators proposed. He explained that insulators of this diameter and larger have been in use on the Pacific Coast, giving good service; and they are just as sturdy as the standard 10-in. suspension insulator.

N. B. Obbard (of the American Bridge Company) discussed this subject in its relation to tower design. He believes this paper is one of the first in which the economic relation of the insulator string to the cost of the tower has been taken into consideration, and that both insulators and tower design should be considered at the same time and not as separate problems.

Another discussion of this subject by A. O. Austin (Barberton, Ohio) also pointed out that with the more efficient insulator it is possible to reduce the clearances and the height of tower, so that the probable number of hits to the line will be less. Also with less clearance the line reactance is reduced and capacitance is increased, so that more power may be transmitted and the stability bettered.

In connection with the part of this paper which deals with the question of diameter and spacing, Philip Sporn (New York, N. Y.) believes that the value of this information would have been greatly enhanced had the tests been confined to practical designs and to spacings and diameters within the commercial range.

W. L. Lloyd, Jr. (Pittsfield, Mass.) discussed the wave shapes used for the tests in this paper. With regard to the wave shape shown in Fig. 1-B, he believes that

sparkover of a test piece would take place at or near the crest of such a wave or not at all; consequently, high sparkover values and impulse ratios are obtained. The laboratory wave shown in Fig. 2, he believes, should give values lower than those measured in the field.

FLASHOVER VALUES OF INSULATORS

A. O. Austin (Barberton, Ohio) in discussing the subject of normal frequency flashover values of insulators as affected by humidity and size, explained that there are so many factors involved which affect the flashover of an insulator that general laws cannot be established which apply to all types of insulators. The correction for humidity therefore must be determined largely by test on the particular insulator or one approximating its general characteristics.

Philip Sporn (New York, N. Y.) believes that this paper checks closely with the information furnished by Mr. Lloyd's paper. He believes that plotting data on the behavior of insulators under different humidity conditions against abscissas of vapor pressure is certainly the most scientific manner of presenting the data.

Another discussion of this subject by J. C. Rah (Chicago, Ill.) brought out that the results obtained on insulators from experiences of many observers indicated that air spaces are responsible for reduced flashover rather than wet surfaces, and therefore the wet flashovers are entirely a function of design.

Summarized Review of Some Winter Convention Discussions—Continued

PRINCIPAL discussions of the majority of winter convention papers were summarized in ELECTRICAL ENGINEERING for April 1932, p. 272–9. The remainder is presented herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for January 1932, p. 39–49 and February 1932, p. 130–2, excepting only the papers given more complete treatment in these same issues; additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the TRANSACTIONS.

Electrical Machinery

PARALLELED ROTOR AND STATOR

In connection with this subject H. B. Hall (New Haven, Conn.) pointed out that the same performance as the authors obtain may be secured from a normally connected induction motor by running it on $\sqrt{2}$ times normal voltage. This, he explained, could be done to any induction motor even if its rotor and stator were wound for different voltages or if it had a squirrel cage rotor.

R. E. Hellmund (East Pittsburgh, Pa.) considered the probability of this special arrangement being used for general purpose work which he believes does not seem likely because usually the same results can be obtained with the ordinary induction motor. Nevertheless he thinks it might be useful in special cases, as, for instance, where speed-torque characteristics as shown in Fig. 12-C of the paper are desirable; therefore the publication of the results obtained should be considered a welcome contribution to the art.

C. L. Fortescue (East Pittsburgh, Pa.) also discussed this subject and analyzed conditions by the method of symmetrical coordinates. It was shown that the output for the same copper loss was increased 41.4 per cent. To offset this the inductance was doubled but the rotor iron loss and the stator iron loss would have approximately the same magnitude, so that the iron loss for the same applied voltage would be approximately double that in the regular induction motor.

DAMPER WINDINGS FOR MOTORS

M. R. Lory (East Pittsburgh, Pa.) said that the problem of the designer was to meet the torque requirements of the load and still keep the current drawn from the line to a minimum. He believes the paper gave a comprehensive summary of the various means by which the designer can accomplish this result. As a matter of interest in connection with two double-deck arrangements in the paper the discusser explained that he had calculated these two examples with two bars in parallel but in separate slots, making the permeance of the slot above each the same as the permeance which it has in the arrangement given in Fig. 7 of the paper. The values of the constants for the two bars were given.

Another discussion of this subject by R. E. Hellmund (East Pittsburgh, Pa.) answered the question as to why the various exciter and phase-advancer schemes for induction motors have not been commercially exploited in this country. He expressed belief that this paper is further evidence of the excellent progress which continuously has been made by American designers of synchronous motors in the development of motors suitable for the many commercial applications.

POWER TRANSFORMER DESIGN

R. E. Hellmund (East Pittsburgh, Pa.) in his discussion of this subject drew comparisons between the methods of surge testing now arrived at in this country, and those which were in effect with most manufacturing concerns in Europe during the summer of 1925. The practise now arrived at in this country is, as a result of the more deliberate method of developing it, in marked contrast to the European methods, and in regard to transformers, it is much more rigorous.

F. W. Peek (Pittsfield, Mass.) in his discussion of this subject attributed the paper by Palueff and Hagenguth as one of a pioneer series which has placed the subject of transients in transformer windings upon a scientific and engineering basis. In the light of new knowledge resulting from this series of papers the discusser again recommended that the committee on electrical machinery set up methods, waves, etc., for making a lightning test on transformers if such a test should seem desirable.

Another discussion by C. L. Fortescue (East Pittsburgh, Pa.) reviewed the historical background leading up to the present development of surge-proof insulation and winding in transformers. The other phase of Mr. Fortescue's interesting discussion predicted in the light of present knowledge the magnitude of the surges to which a transformer might be exposed in certain situations. His remarks were confined to transformers designed for 110-kv. operation, and the analysis considered only direct strokes on both wood pole and steel tower line construction. The latter was classified into three conditions, namely, unprotected lines, imperfectly protected lines and well protected lines.

F. W. Gay (Newark, N. J.) discussed this subject and proposed to provide a transformer with a resistance path in parallel with a winding to be protected, and electrostatically couple the resistance path with the winding and with the transformer terminals, so that relatively very great currents will pass to charge the winding for high frequency surges but relatively insignificant current will pass through the resistance at normal frequency. A surge winding of relatively few turns with the high frequency winding coupled to the transformer terminals by condensers also could be wound in juxtaposition with the many-turn low-frequency high-voltage winding. Thus an advantageous shunt path of very low surge impedance would be provided through the condenser and high-frequency few-turn surge winding.

A. B. Hendricks, Jr. (Pittsfield, Mass.) did not believe that some of the fundamental improvements claimed in the surge-proof construction were new. He submitted drawing of several test transformers, one of which he designed, built and put in service in 1906 to exemplify the fundamental principles involved. He described the winding which was of the concentric form with circular coils with insulation varied more or less in proportion with the voltages. By the use of interleaved cylinders, flanged rings and formed insulating casing, it presented an absolute barrier between the high voltage winding, low voltage winding, and core.

Electrochemistry and Electrometallurgy

LOSSES IN ELECTROLYTIC CONDENSERS

J. Slepian (East Pittsburgh, Pa.) discussed this paper and he told of work which he carried on about twelve years ago in connection with the high power factor usually obtained. He found that the ad-

dition of a fractional per cent by weight of a soluble fluoride had an extremely beneficial effect upon the power factor and reduced the losses so that cells were made with power factors under 2 per cent. However, these cells with superposed d-c. excitation would not stay efficient and in the course of a year the power factor would become 5 or 6 per cent, and it would continue to rise slowly for years afterward. Investigation showed that there was a change in electrolyte which was assumed to have been the formation of colloidal aluminum hydroxide and the inquiry was made as to why such a substance should effect the losses in the cell.

H. H. Race (Schenectady, N. Y.) also discussed this paper with reference to an explanation of the power-factor frequency characteristics of electrolytic capacitors. He believes that if the coefficients of capacitance and resistance in Fig. 25 of the paper could be assumed to be independent of frequency then the complicated combination of series and parallel arrangements of resistance and capacitance could be reduced to an equivalent circuit. On the other hand he does not believe that the coefficients in Fig. 26, which may be only a special case of a more general form, could be assumed to be independent of frequency since the ionic concentration at a given point in the oxide film would change with time.

Electrical Precipitation

J. J. Torok (East Pittsburgh, Pa.) discussed this subject and believes that the authors presented very effectively the results of their experiments. He reviewed a treatise on this subject by Ladenburg which attacked the problem from a different point of view than that taken by the authors of this paper. From this analysis it was found that in precipitators the larger particles would be removed first and as time progressed the smaller particles also would be taken out.

Another discussion by J. C. Hale (Bound Brook, N. J.) took exception to a number of conclusions reached in the paper as well as some of the authors' equations. One of the points questioned by the discusser concerned the mathematical analysis leading to eq. 15 in the paper which shows that identical efficiencies will obtain whether precipitator units be connected in series or in parallel or in series parallel with respect to gas flow, provided the gas is properly divided in the case of unsymmetrical arrangements. For example, in a problem requiring a very low friction loss, eq. 15 points to the use of a large number of units in parallel. The discusser explained that it could be shown mathematically that the combined efficiency of parallel units decreases rapidly as the gas distribution becomes unequal. Equal distribution of gas through too many parallel units was believed to be most difficult and the selection of a proper number of units to be parallel was therefore not a matter of efficiency calculated on the basis of any formula, but a matter of experience with regard to distribution. The discusser felt that in justice to the scientists and engineers who have devoted much work to the art that the part of the authors' conclusion which referred to work done heretofore should be sincerely questioned.

Transportation

Three-Power Locomotives

W. S. H. Hamilton (New York, N. Y.) discussed the requirements and performance of these locomotives used by the New York Central around New York City. He explained that the size of the internal power plant (300 engine hp.) was based on requirements in the 60th Street yard where there was heavy switching and float work. With regard to the ability of the internal power plant to meet emergency conditions it was explained that these locomotives successfully handled 2,000-ton trains in regular road service over a distance of 8 miles for a period of 11 months. It was pointed out that for the year 1931 the whole fleet of 36 locomotives was in service with crews on 61 per cent of the time and were available for service 85.5 per cent of the time. This performance with new locomotives and new crews was considered very creditable.

Another discussion of this paper by D. P. Orcutt (New York, N. Y.) considered the expected battery life on the three-power locomotive as compared with the straight storage battery locomotive for switching service. Data on the operation of the first three-power locomotive on the New York Central showed that in switching service about 85 per cent of the energy used by the traction motors flowed directly from the generator to the motors and 15 per cent from battery to the motors. This permits the use of a much smaller battery with a three-power unit, thus greatly reducing battery maintenance cost from that with a straight battery locomotive in switching service.

F. H. Craton (Erie, Pa.) discussed this subject and briefly described requirements in connection with the New York Central's west side improvement which were largely responsible for the development of the three-power locomotive. In comparing the three-power locomotive to the two-power design it was brought out that the engine-generator-battery type was best fitted for operation in service where peak demands are high and the load factor low. The three-power type also possesses the additional advantage of being able to operate on battery power into buildings or restricted areas.

F. H. Brehob (Erie, Pa.) also discussed the subject and described a number of the difficult problems in mechanical design that had to be solved to meet the severe service requirements. The locomotive as developed represents the heaviest four-axle swivel truck locomotive in service today and it utilizes the heaviest axle loading using single-geared axle-hung motors. The weight in working order was limited to 257,000 lb. by utilizing material to best advantage.

Herman Lemp (New York, N. Y.) also discussed the paper and considered the advantages of another engine equipment of 300 hp. to take the place of the battery. He explained that this would not cost or weigh more than the battery which was good only for four years, while the engine equipment if properly maintained would be available at least for ten years.

Temperature Rise of Railway Motors

John Basta (East Pittsburgh, Pa.) discussed this subject and explained that the actual heat runs used for verifying the calculated curves, however, did not give more than two, and in some cases even only one point. It was suggested that the author undertake another series of tests in which complete curves would be obtained. Instead of measuring the resistances of armature windings, as was done in the tests

On Program for the Pacific Coast Convention

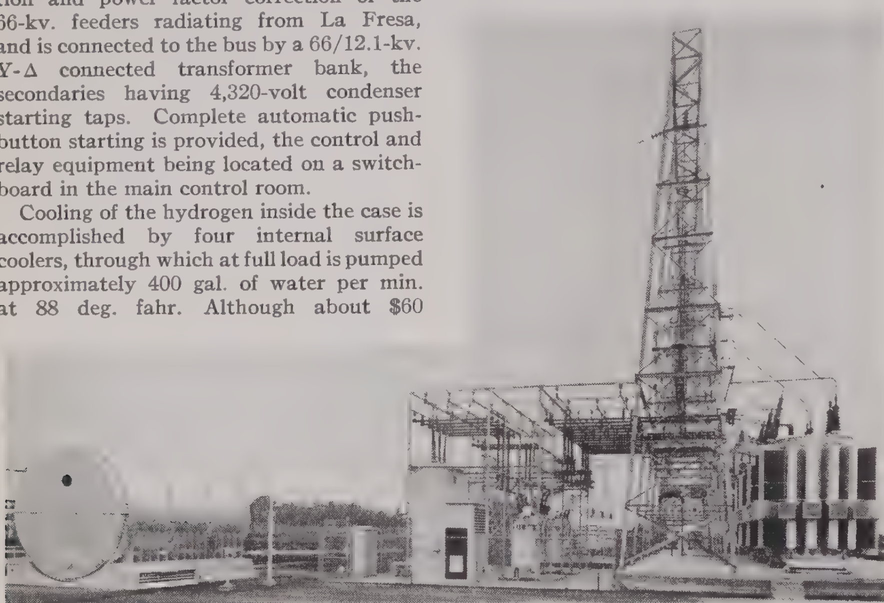
THE RUSKIN hydroelectric plant of the British Columbia Electric Railway Company may be visited by those attending the A.I.E.E. Pacific Coast convention which is planned to be held Aug. 30–Sept. 2, 1932, at Vancouver, B. C. One 47,000-hp. unit is now installed in the Ruskin plant, the ultimate capacity of which will be 188,000 hp. in four units.

50,000-Kva. Hydrogen-Cooled Condenser at La Fresa

REDUCTION of noise, reduced operating temperatures, decreased windage losses, increased efficiency, saving in installation cost, and elimination of the requirement for special fire-fighting equipment are among the benefits secured with this outdoor hydrogen-cooled synchronous condenser. Located at the La Fresa substation of the Southern California Edison Company, Ltd., this condenser is rated 50,000 kva., and is the largest hydrogen-cooled unit ever constructed. It is used for voltage regulation and power factor correction of the 66-kv. feeders radiating from La Fresa, and is connected to the bus by a 66/12.1-kv. Y-Δ connected transformer bank, the secondaries having 4,320-volt condenser starting taps. Complete automatic push-button starting is provided, the control and relay equipment being located on a switchboard in the main control room.

Cooling of the hydrogen inside the case is accomplished by four internal surface coolers, through which at full load is pumped approximately 400 gal. of water per min. at 88 deg. fahr. Although about $60 worth of hydrogen is needed to fill the machine, the cost of make-up hydrogen has averaged less than 10 cents per day during the first 4 months of operation.

The condenser and starting and running circuit breakers were manufactured by the General Electric Company, and the transformers by the Westinghouse Electric and Manufacturing Company. Four 1,250,000-cir. mil. 16-kv. Kerite insulated cables in parallel are used for each of the three main condenser leads.



presented, it was suggested that temperature detectors be placed into the winding which would be connected through slip-rings to meters, so that the distribution of temperatures along the winding could be ascertained at the same time.

C. J. Fechheimer (East Pittsburgh, Pa.) discussed several of the author's assumptions made in the paper. It was believed essential to make assumptions such as the author had done although these might not be the ones to adopt for some other class of apparatus. It was explained that the author's results were all based upon the average copper temperature as measured by resistance. For machines having long cores, the copper at the middle is usually at considerably higher temperature than the average, and consequently assumption *B* in the paper would introduce too large an error.

SECTIONALIZING OF RECTIFIER

A. W. Hull (Schenectady, N. Y.) discussed the part of the paper which related to the fundamental limitation of rectifiers, namely, the prophecy that "the major disadvantages which go with size appear to be fundamental and permanent. Larger units will always be less efficient and probably less reliable." He explained why theory and present experience did not seem to him to justify this conclusion. He believed that if large rectifiers were at present less efficient than small ones, it was a mere chance which was due to the relative state of development, and not a fundamental limitation of large rectifiers.

R. E. Hellmund (East Pittsburgh, Pa.) discussed the reliability and availability of the sectionalized designs versus large units. He cited as an analogy, discussion which took place in the early days of a-c. main-line electrification regarding the relative merits of locomotives having one or two large motors and those having many small motors. Practical experience showed that the reliability and availability with the large motors was low because such unavoidable accidents as the breaking of a single carbon might damage the commutator and keep the locomotive out of service. On the other hand a similar occurrence in the locomotives having many small motors, that is, sectionalized power, permitted quick replacement and much greater availability of the locomotives.

Another discussion by C. A. Butcher (New York, N. Y.) explained that heretofore he had not been an enthusiast for mercury arc power rectifiers but the advantages of the new development described in the paper and the indications, from extensive research laboratory work and testing, of a higher order of reliability have lead him for the first time to be enthusiastic about a rectifier.

W. E. Gutzwiller (Milwaukee, Wis.) also discussed this paper and it is his belief that the claims made for this rectifier were somewhat overemphasized. He pointed out that experience has shown that small sectional types have usually been later supplanted by large single-tank types for reason of simplicity and reliability except in very special cases where other considerations were dominant. This, he believes, is particularly true on fluctuating loads, such as heavy traction service where a real gain in reliability is of more importance than a slight gain in efficiency.

Symposium on Time and Time Services

L. S. Harrison (New York, N. Y.) described a master clock system which hourly supervises the uniform agreement of electric secondary units. In this system the master clock, with a high-grade 60-beat pendulum regulator which is capable of rating within 2 to 3 sec. per month, transmits over an individual three-wire system its own accuracy to the secondary time pieces, both as to rate of advance and as to a point origin of time by means of a periodic time check. The system was introduced in 1924 and it has had wide application throughout the United States and Canada.

The inventions of Mathias Hipp, who was a pioneer in the art, were interestingly brought out by Herman Lemp (New York, N. Y.) in his discussion of this subject. It was explained that Mathias Hipp's electric clocks are known all over Europe. They have been in continuous service in the principal cities of Switzerland since about 1868 and furnish accurate time to a critical public, makers of Swiss watches and chronometers. This inventor was also the first to construct an astronomical pendulum of steel with mercury compensation.

J. D. Crawford (Cambridge A, Mass.) in his discussion of this subject referred to the series of experiments undertaken by the late Dr. A. A. Michelson. These experiments involved the determination of the time it took light to travel ten times between two sets of mirrors placed at the ends of an evacuated tube about a mile long. In making these measurements a crystal clock was used as the reference standard.

TELEGRAPH TIME SERVICE

In connection with this subject W. A. Dudley (New York, N. Y.) explained that usually one or more synchronized clocks in each office of the telegraph companies are provided with cam-operated contacts which, through suitable relays, are used for the control of timing and dating stamps. Thus these clocks, which are part of a synchronized time service described in the paper, provide an accurate means for controlling and checking the speed of service.

J. C. Wilcox (New York, N. Y.) also discussed this paper and referred to the movements, construction, and application of the subscribers' clocks. He pointed out that these clocks are independent operating units with the ability to operate continuously and accurately regardless of outside line interruptions. He explained

that these self-winding clocks were found on every railroad and subway system in New York with the largest installation in the Grand Central Terminal where over 1,000 units are operated.

Another discussion by R. C. Thayer (St. Paul, Minn.) brought out the value of the noon beat signals as sent out by the two telegraph companies to the railroads of this country. These signals are redistributed throughout the railroad companies networks of communication circuits so that each of the railroad stations and train dispatchers receive the correct time daily.

Synchronous Electric Time Service

This subject was discussed by Philip Sporn (New York, N. Y.) who believed that a reading of the paper was likely to give the wrong impression—that the question of frequency control by operators of large power systems was a simple matter, involving little more than the use of a master clock. Some of the difficulties involved in frequency regulation on an interconnected system were explained by the discusser and illustrated by load charts of a tie line which showed the wide fluctuations caused by close frequency regulation.

R. J. Wensley (Newark, N. J.) also discussed this subject and brought out that the first interest displayed by the central station industry in synchronous timekeeping was in the use of such methods for the integration of demand against definite time intervals. He also pointed out that at present the usual power system is not regulated with sufficient accuracy to permit the use of synchronous timing of extremely short intervals.

The Bonbright Survey of electric light and power companies of the United States, eighth edition, revised September 1931, recently was issued by the McGraw-Hill Publishing Company, Inc., of New York. According to the foreword in this volume the first edition of the survey was compiled in 1923 by Bonbright and Company, Inc., investment bankers closely identified with the electric power and light industry. Since January 1926, the publication has been compiled and issued by the McGraw-Hill company. In the present edition, corporate relationships and territories served are given as received until November 1931, in reports from the power companies concerned, while financial statistics are given, so far as was possible, as of June 30, 1931. The list of holding corporations and subsidiary companies has been revised; financial data have been augmented to include more of the municipal and smaller privately owned properties; listings of incorporated cities and towns having a population of not less than 2,500 have been augmented to include results of the 1930 census. The published price is $10 per copy.

Successor to C. L. Edgar Appointed.—Announcement has been made of the election of W. C. Baylies as president of the Edison Electric Illuminating Company of Boston, Mass., at a special meeting of its directors. He succeeds C. L. Edgar (A'96, F'12) who died suddenly April 14, 1932. Mr. Baylies graduated from Harvard in 1884, and previously was vice-president and chairman of the executive committee of the Edison Electric Illuminating Company.

Forty Years of Manufacturing

At the annual meeting of the General Electric Company at Schenectady, N. Y., President Gerard Swope (A'99, F'22) cut a birthday cake in observance of the company's fortieth anniversary. In April 1892, the General Electric Company was formed by the consolidation of the Thomson-Houston and the Edison General Electric companies. The figure "40" composed of ornamental electric lights decorated the top of the cake.

Southern California Utility Pioneer Dies

On the same day that the electric utility industry in the East lost one of its leaders of long standing through the death of C. L. Edgar of Boston, Mass. (see p. 359–360 this issue) a similar loss occurred on the Pacific Coast in the death of John Barnes Miller, chairman of the board of directors of the Southern California Edison Company, Ltd. Mr. Miller, who was 62 years of age, died on April 14, 1932, at Los Angeles, Calif.

After studying at the University of Michigan, Mr. Miller returned to his native city of Port Huron, Mich., in 1890, but after a few years' business experience there and in Louisana, went to California in 1896. In 1898 he was elected treasurer of the Edison Electric Company, later the Southern California Edison Company, becoming its president three years later. After being both president and chairman of the board for many years, he resigned the former position in 1928. He was also an officer and director in several other companies, and in 1925 was elected a vice-president of the National Electric Light Association.

Mr. Miller symbolized the pioneer spirit of the West, and under his direction many small companies were consolidated and reorganized into one company noted for its soundness as well as for its ease of operation. Teamwork among employees and customer ownership of stock were encouraged, much of the pioneer work in this latter activity having been done by Mr. Miller.

A.S.M.E. to Hold Meetings

The sixth annual aeronautic meeting of The American Society of Mechanical Engineers will be held at the Hotel Statler, Buffalo, N. Y., June 6–8, 1932. The technical program will include some 30 papers and reports covering aerodynamics, navigation, engines, airplane carriers, design, and fuel. The technical sessions will be held on Monday and Tuesday, with Wednesday open for various plant inspection trips and a sightseeing tour around Niagara Falls.

At the same time, Buffalo will be host also to the first national process meeting of The American Society of Mechanical Engineers, with technical sessions on Monday and Tuesday, and the same trip to the Falls scheduled for Wednesday.

The American Society of Mechanical Engineers, with the cooperation of the Engineering Institute of Canada, will hold its 1932 spring meeting at Bigwin Inn, Lake of Bays, Ontario, Canada, June 27–July 1, 1932. This year the scope and magnitude of the meeting will be expanded and it is expected that it will include papers illustrative of British, Canadian, and American engineering practise.

Among the special trips available is a tour leaving New York, N. Y., on June 26 and Toronto, Ontario, Canada, on June 27. At the conclusion of the convention the trip will include seven additional days by boat and railroad through some of the most picturesque sections of Canada.

Control of Foreign Investments

Because of its importance to citizens of this country who have investments abroad, and because of its close relation to the problem of investments in engineering projects undertaken within the limits of this country, the following editorial from the April 14, 1932, issue of *Engineering News-Record*, p. 533, is reprinted herewith in full:

"Engineering Advice Needed"

"A service to the country generally has been done by the American Institute of Consulting Engineers in a statement addressed to the Senate finance committee giving pertinent facts concerning the investment of capital in Latin America. The

Senate finance committee has been investigating conditions surrounding the investment of funds from this country in foreign fields to determine why many investments so made have turned out to be a failure. It sought to learn where responsibility for this development lay. The Institute's (A.I.C.E.) report—prepared by engineers of long experience in Latin America—places responsibility squarely on the bankers for failure to get disinterested opinion on the soundness of the ventures they were financing and to set up proper checks upon the way money was spent.

"Money has been loaned to Latin American governments in the belief that it was to be used to construct useful public works without knowledge as to the need for or revenue-producing value of the proposed works, without stipulation that the money was to be spent only upon approved work, and without providing for proper control of its expenditures. As far back as 1919 the Institute (A.I.C.E.) began urging upon American bankers the desirability of universal adoption of a practise followed by most British bankers but by only a very few in America—namely, employing independent consultants to pass upon the feasibility of projects for which they have been asked to provide funds. If after investigation the project appears attractive, British bankers do not pass out the money without stipulating that they retain control over the manner in which it is spent, and usually even over the operation of the project when completed. A second time in 1923, again in 1928, and once again in 1929, the Institute (A.I.C.E.) urged the adoption of this practise upon the principal investment houses of this country. Their warnings went without effect.

"The bankers, it appears, saw only the Institute's (A.I.C.E.) selfish interest in urging engineering investigation and control and so ignored it, being content to take any bond issue that came along regardless of its merit so long as they could make a profit out of the underwriting, passing the bonds on to the trusting public which, in the end, 'holds the bag.' The folly of that practise is now all too obvious. Much of the money so invested has been squandered on ill-conceived undertakings, investors in this country have lost or stand to lose most or all of their principal, and confidence in the banking houses that sold them the bonds has been lost. Distrust of all Latin American investments has been developed. But worst of all, international distrust and ill-will have been built up just at a time when trust and good-will are most needed.

"A frank and convincing statement of what could have been done to protect American investments abroad, even though it comes from an interested party, cannot but help to insure the adoption of sound practises in the future. The Institute (A.I.C.E.) is to be congratulated for having risked arousing antagonism among bankers in order to put the facts clearly before the public."

Letters to the Editor

Heart Injury From Electric Shock

To the Editor:

I have read the Kouwenhoven article, "Heart Injury From Electric Shock," in the April 1932, issue of ELECTRICAL ENGINEERING, p. 242–4. Are we publishing an engineering journal or a medical journal devoted to vivisection?

I deplore the efforts of Doctor Kouwenhoven to link the American Institute of Electrical Engineers with vivisection and kindred surgical work. It is not our natural field and I do not believe the rank and file of our members approve of this excursion into territory so far removed from engineering.

Yours very truly,
F. G. STRONG (A'91, F'13 and Life Member) 120 Hartford Ave., Wethersfield, Conn.

Nerve Injuries From Electric Shock

To the Editor:

I should like to commend ELECTRICAL ENGINEERING for the breadth of view shown in publishing the article "Nerve Injuries from Electric Shock," in the December 1931, issue, p. 929–32.

To me the article was of great interest and I welcomed it as being a genuine contribution toward the goal of resuscitating all who are so unfortunate as to receive violent electric shocks. The more not only members of the medical profession but also the laymen like ourselves know about the physiological effects of electricity, the more successful we are likely to be in reviving a person who has received an electric shock, in case, at any time we are confronted with such an emergency.

Very truly yours,
D. W. ROSEBRUGH (A'23, M'29) (22 Baker St., Poughkeepsie, N. Y.)

Suggested Changes in Dielectric Nomenclature

To the Editor:

In the study of dielectrics, the following names are suggested as being more logical than those now in use:

1. "Capacitance factor" is proposed to replace "dielectric constant."
2. "Loss factor" is given a slightly different meaning from that previously used.
3. "Capacitivity" is suggested to replace "permittivity" in systems of units where the latter quantity is now used.

There are always objections to changes in nomenclature, especially when such changes are suggested for names of concepts of long standing. Nevertheless our language is continually changing, so that suggestions for simpler or more logical terms should be encouraged and carefully considered in order that the best possible picture of a field of study will be conveyed by the nomenclature used.

From an experimental point of view an imperfect dielectric may be represented in terms of an equivalent parallel circuit of resistance and capacitance; in fact, most determinations of the a-c. properties of dielectrics employ bridge or substitution methods of measurement in which the characteristics of the sample are measured in terms of resistors having negligible distributed capacitance and capacitors having negligible loss in series or parallel combinations. The complex expression for the experimentally determined electrical properties of the dielectric is then

$$Y = G + i\,w\,C \qquad (1)$$

where G, the equivalent parallel conductance, is a measure of the component of current in phase with the applied potential, and therefore of the total dielectric loss by whatever mechanism it may be produced. Also C, the equivalent parallel capacitance is a measure of the component of current in leading quadrature with the applied potential and therefore of the total charge stored per cycle per unit potential. From a theoretical point of view, Debye ("Polar Molecules," p. 94, The Chemical Catalogue Co., 1929) has used a set of symbols from which the expression corresponding to eq. 1 is

$$Y = i\,w\,C_v\,(\epsilon' - i\epsilon'')$$

which when expanded gives

$$Y = \epsilon''\,w\,C_v + i\,\epsilon'\,w\,C_v \qquad (2)$$

In this relation two new names are suggested, namely, capacitance factor, ϵ', and loss factor, ϵ''; the relation between them gives the well-known and generally used quantity

$$\text{Power factor} = \sin\left[\tan^{-1}(\epsilon''/\epsilon')\right] \qquad (3)$$

The first named or capacitance factor is defined by the relation

$$\epsilon' = \frac{C_x}{C_v} \qquad (4)$$

and is the ratio of the capacitance of the sample to the capitance of a vacuum space of the same size and shape. Generally this is called the specific inductive capacity or the dielectric constant of the material, but there are two objections to the latter name, which is most commonly used: First, ϵ' is not constant, but varies with temperature because of changes in density and with frequency if the sample contains polar molecules which can move in a viscous medium. Therefore it might better be called a coefficient or multiplying factor rather than a constant. Attention already has been called to this misuse of words by G. L. Addenbrooke (*Nature*, v. 126, Nov. 22, 1930, p. 808). Second, the word "dielectric" is general whereas the word "capacitance" specifically refers to the storage of charge or the component of current in leading quadrature with the applied potential. Therefore it seems that "capacitance factor" is more descriptive of the true meaning of the quantity ϵ'.

The second of the two factors or loss factor, is defined in terms of experimental data by comparing eq. 1 and 2 from which

$$\epsilon'' = G/w\,C_v \qquad (5)$$

In general, ϵ'' is proportional to the loss per cycle per unit volume. It may be a function of all the experimental parameters, and in no way implies the mechanism or

cause of the dielectric loss, of which it is a measure. There is precedence for the name "loss factor" ("A.S.T.M. Report of Committee D-9 on Electrical Insulation," 1931, p. 93), since it has been used to express the product of the dielectric constant and the power factor in per cent.

For small loss angles power factor $= G/\omega\epsilon' C$ so that by the A.S.T.M. definition the loss factor will be the same as given by eq. 5. For large loss angles, however, my definition will have a clearer physical meaning since ϵ'' is taken to measure only the loss, independent of the capacitance, whereas the A.S.T.M. definition is influenced by the capacitance because power factor is defined exactly as the sine rather than the tangent of the loss angle.

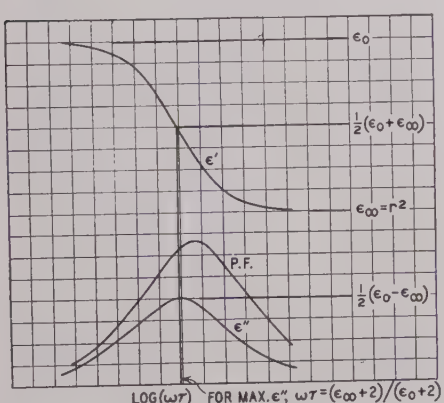
Capacitance factor and loss factor are coefficients which vary as different functions of the experimental variables, and therefore a better understanding of the electrical properties of an insulating material can be obtained by studying each separately, than by studying power factor, which according to eq. 3 involves both. For example, according to Debye's theory of polar molecules, the variation of these two factors with frequency is given by the following relations (H. H. Race, *Phys. Rev.*, v. 37, Feb. 1931, p. 441):

$$\epsilon' = \frac{\epsilon_0(\epsilon_\infty + 2)^2 + \omega^2\tau^2\epsilon_\infty(\epsilon_0 + 2)^2}{(\epsilon_\infty + 2)^2 + \omega^2\tau^2(\epsilon_0 + 2)^2} \qquad (6)$$

$$\epsilon'' = \frac{\omega\tau(\epsilon_0 - \epsilon_\infty)(\epsilon_\infty + 2)(\epsilon_0 + 2)}{(\epsilon_\infty + 2)^2 + \omega^2\tau^2(\epsilon_0 + 2)^2} \qquad (7)$$

where
ϵ'_0 = capacitance factor at zero frequency
ϵ'_∞ = capacitance factor at infinite frequency
ϵ_∞ = (index of refraction)^2
τ = relaxation time

The above subscripts differ from those used by Debye and refer directly to the frequency at which the measurement is made.



Capacitance factor (ϵ'), loss factor (ϵ''), and power factor (P.F.) for a hypothetical polar liquid, using Debye's theory for case where $\epsilon_0/\epsilon_\infty = 2$.

To illustrate the variations of these three factors with frequency, the accompanying curves have been drawn for a hypothetical polar liquid in which $\epsilon_0 = 2\,\epsilon_\infty$. The power-factor curve is plotted to ten times the scale used for the other two, and illustrates the fact that this function is more complicated than ϵ'' and that it is less difficult to determine the frequency for maximum loss factor than the frequency for maximum power factor as has been done by Whitehead (*Phil. Mag.*, v. 9, 1930, p. 865).

While I am discussing nomenclature for dielectrics, there is one more name which I should like to propose; the capacitance of a unit cube of dielectric is called its permittivity by some writers, but the name "capacitivity" seems much more appropriate. The word "permittance" is not in general use, while the word "capacitance" has been almost universally accepted. Therefore the capacitance per unit volume might better be called capacitivity. The accompanying table shows that this name is consistent with our present scheme of nomenclature:

Conductor	Resistor	Capacitor
Conductance	Resistance	Capacitance
Conductivity	Resistivity	Capacitivity

Thus the capacitance of a homogeneous dielectric is given by the following relation

$$C = \epsilon' C_v = \epsilon'\epsilon_v\,(a/l) \qquad (8)$$

where ϵ_v = capacitivity of vacuum and a and l are, respectively, the effective area and length of the dielectric field. Thus the capacitivity of any dielectric is its capacitance factor multiplied by the capacitivity of vacuum; ϵ_v may be considered to be dimensionless and equal to unity or having both a dimensional formula and a numerical value, depending upon the system of units used. However, capacitance factor, loss factor, and power factor as defined are numerics in all systems of units.

Very truly yours,
HUBERT H. RACE (A'24)
(Research Engineer, General Elec. Co., Schenectady, N. Y.)

Engineering Foundation

Personnel Research Federation Active

Toward meeting unemployment, the Personnel Research Federation, now over ten years old, has cooperated with agencies throughout the country by assembling and distributing information as to the methods of studying and dealing with employment. A conference was held jointly with the Social Science Research Council to determine the effects of part-time and lay-off on workers' efficiency and morale. Various other researches and investigations have been suggested and undertaken.

Continuing the investigation of causes and treatment of accident proneness on highways and in factories, a study has been made of accident susceptibility among 5,000 drivers over a 5-year period. In cooperation with the National Safety Council and other agencies, the Federation has undertaken to concentrate efforts on the diagnosis and cure of the relatively small proportion of the population who appear to be prone to accidents.

Studies Made of Engineering Education

Studies of engineering education made by the education research committee of Engineering Foundation have been facilitated by cordial cooperation from coast to coast. Proposals for fundamental improvements are being examined by educational and engineering societies under the leadership of the Society for the Promotion of Engineering Education. Progress has been made on giving information to serve as a guide in the selection of a vocation.

A pioneer demonstration of another method was given by H. N. Davis, chairman of the committee and president of Stevens Institute of Technology. In August 1931, a camp for high school boys was conducted for two weeks, during which time simple examples of engineering and talks by different engineers were given, supplemented by a large variety of tests. The experiment was declared a success and is to be repeated in 1932.

The committee has given assistance also in the formulation of practical tests intended to appraise the qualifications of youths and men for various occupations. Other studies are receiving consideration and the committee is cooperating with the American Council on Education, and is continuing aid to the summer schools which are being conducted for engineering teachers by the Society for the Promotion of Engineering Education.

American Engineering Council

Pending Patent Legislation

Considerable legislation affecting the granting of patents and patent office procedure has been introduced into the present Congress. The views of American Engineering Council's patents committee have been given by its chairman, E. J. Prindle (A'06, M'20) to Congressman W. I. Sirovich, chairman of the committee on patents of the House of Representatives. Some of the more important bills, with the opinions transmitted by Mr. Prindle, are given below:

H. R. 10,152—To empower the assignees of inventor to file divisional, continuation, renewal, or reissue application. This bill is favored as an efficient simplification of procedure. The original bill has been superseded by H. R. 11,018, and slightly amended by the insertion of a clarifying phrase.

H. R. 10,153 superseded by H. R. 11,016—To limit the life of a patent to a term commencing with the date of application. Opposition to this bill was expressed because it does not give sufficient regard to the circumstances of the particular application for patents.

H. R. 10,154 superseded by H. R. 11,017—Permitting single signature in patent applications and validating joint patent for sole invention. This is considered a wise and constructive measure.

H. R. 10,155—To abolish the statute permitting renewal of patent applications. This bill was approved by Mr. Prindle, and the patents committee of the House has voted to report out the bill.

H. R. 10,156 superseded by H. R. 11,019—To limit inventors to priority of two years before filing application for patents. In effect this bill cuts down to a term substantially below two years the period in which the patentee might try out his invention on the market before applying for a patent. An extension of this limit to three years was suggested.

H. R. 10,157—To expedite prosecution of patent applications pending more than three years. This bill has been reported by the patents committee, and is supported by a special committee which carries very considerable weight and authority.

Engineering Council Formed at Los Angeles

Local chapters of the four national engineering societies in Los Angeles, Calif., recently formed the "Los Angeles Engineering Council of Founders Societies." The preamble to its constitution is identical to that of American Engineering Council and reads: "The object of the Council shall be to further the public welfare wherever technical and engineering knowledge and experience are involved, and to consider and act upon matters of common concern to the engineering profession."

The executive committee is composed of Robert Linton, *president;* Carl Johnson (A'09, F'25), *vice-president;* L. W. Voorhees, *secretary-treasurer;* and A. F. Barnard. Among the other eight members of the council are two members of the Institute, A. P. Hill (A'23, M'29) and Prof. R. W. Sorenson (A'07, F'19).

Muscle Shoals Bill Reported in House

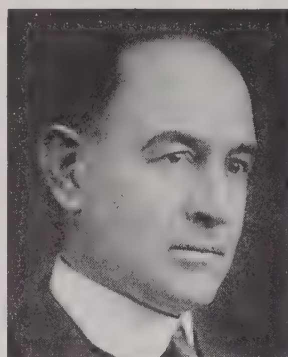
A bill, No. 11,051, introduced by Representative Hill of Alabama, to provide for the leasing and other utilization of Muscle Shoals properties, in the interest of national defense and agriculture, was reported from the military affairs committee of the House of Representatives, April 4, 1932.

The measure is essentially different from the Norris bill in the Senate. It concerns all of the Government owned properties located at and near Muscle Shoals except the power plant and power generating facilities, and provides for a board of three authorized to lease and hold these properties for a period not exceeding 50 years from the date of enactment, and upon such terms and conditions as, in its judgment and subject to the limitations of the act, will best serve the interests of the United States in carrying out the purposes of this act.

Spring Meeting of Administrative Board.—Announcement has been made that the spring meeting of the administrative board of the American Engineering Council will be held May 13–14, 1932, at the Washington Hotel, Washington, D. C.

Personal

W. G. Cady (M'19) professor of physics at Wesleyan University, Middletown, Conn., at a recent election of officers of the Institute of Radio Engineers was chosen to be its president. Doctor Cady is a native of Providence, R. I.; his Ph.B. degree was conferred upon him by Brown University in 1895; his A.M. the following year, and his Ph.D. was received from the University of Berlin, Germany, in 1900. For two years he was magnetic observer of the United States Coast and Geodetic Survey, at Cheltenham, Md., the following year becoming instructor in physics at Wesleyan University, where for some time he has



W. G. CADY

been in charge of all courses in electricity. His work in the piezoelectric field has been conspicuous and in 1928 resulted in his being awarded the Morris Liebmann memorial prize. This prize is an annual award made by the Institute of Radio Engineers and was made possible by a gift of $10,000 to perpetuate the memory of Col. Morris N. Liebmann, a communication engineer who lost his life in the World War; the annual accrual of interest upon this amount constitutes a cash prize of approximately $500, and the award is made for outstanding accomplishment in the field of communication. Doctor Cady has done some very important work in connection with the electric arc submarine signaling and the detection of vibrations due to feeble water disturbances. He also has contributed considerable of importance to research in both physics and electricity and has produced many valuable technical papers.

F. L. Rhodes (A'03, F'13) outside plant development engineer for the American Telephone and Telegraph Company, New York, N. Y., and through a term of service of over thirty years largely responsible for determining the present day standards of the company for outside plant construction, because of ill health retired from active service March 1932. Mr. Rhodes is a native of Boston, Mass., and obtained his B.S. degree from Massachusetts Institute of Technology in 1892. That year he entered the mechanical department of the American Bell Telephone Company of Boston and for several years was occupied chiefly with electrical measurement work relating to telephone transmission over open wire lines and cables; he also did work on the design and development of induction and repeating coils. In 1899 when the department was amalgamated with the engineering department of the American Telephone and Telegraph Company, Mr. Rhodes was chosen to specialize on the design and engineering of the outside plant of the telephone system, and in 1905 was placed in charge of the division of the engineering department responsible for the outside plant engineering. He was one of the principal members of the staff of Col. J. J. Carty. As liaison officer between the telephone companies and the electric light companies he accomplished much valuable work. He has been called upon to give expert testimony in legal cases both in the United States and Canada, and for three years served on the overhead line construction committee of the National Electric Light Association. Mr. Rhodes also has served the Institute on its board of examiners (1915–20), on its meetings and papers (now technical program) committee (1916–17), as chairman of the communication committee for a year besides serving as a member of the committee for three years; and for seven years he was a member of the standards committee.

K. B. McEachron (A'14, M'20) research engineer, L. H. Whitney (A'23) chemical engineer, and F. M. Clark (A'24) physicist, all of the General Electric Company, Pittsfield, Mass., and M. A. Savage (A'21) design engineer, and C. A. Nickle (A'25) an electrical engineer at the company's Schenectady works are participants with eighteen other General Electric employees in the 1932 award of the C. A. Coffin Foundation prize. This Foundation, established in 1922 to perpetuate the name of the founder and first president of the company, awards $11,000 annually for the most signal contributions by employees of the company toward increased efficiency or progress in the electrical art. No matter what the type of work, an employee is eligible for consideration for an award. With each prize is given a certificate of merit. Mr. McEachron received his award for outstanding accomplishment in the invention of Thyrite for use in lightning arresters; Mr. Whitney, for his valuable assistance to Mr. McEachron in this development; Mr. Clarke, for special contributions to the quality as well as reduction in cost, of capacitors; Mr. Savage, for unusual ability in the design and development of large steam driven generators; and Mr. Nickle for his exceptional ingenuity in the development of hysteresis motors of new and improved design.

J. F. Fairman (A'20, M'27) who for the past six years has been assistant electrical engineer for the Brooklyn Edison Company now has become electrical engineer for that company. His progress since joining the Brooklyn Edison Company in 1925 as

assistant outside plant engineer has been marked, as was his advancement in his academic work on the teaching staff of the University of Michigan, from which he was graduated in 1918, and thereafter was first instructor and then assistant professor of electrical engineering. Following his discharge from military duty after the World War, he took the graduate student course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., thereafter returning to the university for further teaching.

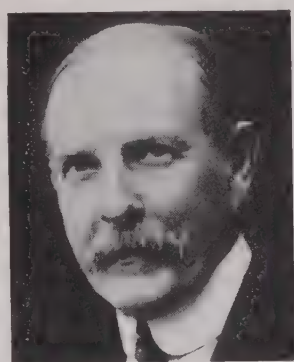
A. L. Nelson (A'16, F'29) who for twelve years has been a member of the firm of Jackson and Moreland, Boston, Mass., as well as manager of its construction department handling problems relating to plant investigation, operation, and construction, now has established a business of his own under the firm name of Arthur L. Nelson Engineers, for the same type of work as before. Mr. Nelson has served several of the engineering groups on committee work, including the A.I.E.E., A.S.M.E., N.E.L.A., and the Boston Society of Civil Engineers of all of which he is a member. From 1920 to 1924 he was on the faculty of the Massachusetts Institute of Technology, electrical engineering department, and gave lectures on power plant design, construction, and operation.

C. L. Law (A'20) general commercial manager of the New York Edison Company, New York, N. Y., now fills a similar position with the United Electric Light and Power Company, of New York. He has been with the Edison company since 1906 in various managerial capacities and received his appointment as general commercial manager in 1929. Only recently he was elected president of the Electrical Association of New York, and through his membership in other representative bodies including the American Association for the Advancement of Science, has been actively executive.

J. R. North (A'21, M'29) who has been assistant investigations engineer for the electrical engineering department of the Allied Engineers, Inc., Jackson, Mich., now has become general engineer of the Commonwealth and Southern Corporation, also at Jackson. Mr. North is serving on the foreign systems coordination committee (national) and various project committees of the joint subcommittee on development and research of the National Electric Light Association and the Bell System.

N. E. Wunderlich (A'27) engineering executive for the R. C. A. Victor Company, Incorporated, at Camden, N. J., recently established a new system for improved radio reception. This system, which bears the name of its inventor and was exhibited with success at the Chicago radio show, consists of a special yet simple circuit and a new type of tube serving the three-fold purpose of detection, amplification, and automatic volume control. Preliminary tests and measurements by two nationally recognized laboratories confirm its claims.

A. E. Kennelly (A'88, F'13, and past-president) professor emeritus of electrical engineering of both Harvard University and Massachusetts Institute of Technology, on the evening of Friday, April 8, 1932, was the recipient of another distinction in the bestowal of the Medal of Honor of the Institute of Radio Engineers, of which he is a past-president. Doctor Kennelly's achievements have been so numerous and so well known that they will not be included here. This latest citation was "for his studies of radio propagation phenomena and his contributions to the theory and measurement methods in the a-c. field which now have extensive radio



A. E. KENNELLY

application." The award itself includes a gold medal suitably engraved and bestowed annually upon "that person who has made public the greatest advance in the science or art of radio communication, regardless of the time of performance or publication of the work on which the award is based." Others who have received this Medal of Honor include Guglielmo Marconi (HM'17) M. I. Pupin (A'90, F'15, HM'28 and past-president) J. S. Stone (A'08) E. F. W. Alexanderson (A'04, F'20) Lee DeForest (A'04, F'18) and others, the first award having been made in 1918.

W. I. Middleton (A'09, M'14) who has been chief electrical engineer of the Simplex Wire and Cable Company for many years, now has retired from office, completing a record of distinction. He has made many valuable original contributions to cable production and application. Mr. Middleton's connection with the company dates from 1903; his work in the cable field includes the pioneering of deep oil well cable and the all rubber covered cable design for mining service. His reputation in cable engineering is world wide.

H. V. Bozell (A'08, F'23) who has been identified for some time with Bonbright and Company, New York, N. Y., and who at one time was editor of the *Electrical World*, now has been elected executive vice-president and a member of the board of directors of the Associated Telephone Utilities Company, a holding company which through its subsidiaries operates some 909 exchanges over properties including 511,000 telephones and about 60,000 miles of toll line in 25 states of the Union

C. R. Beardsley (A'08, F'30) has been appointed assistant to the superintendent of distribution of the Brooklyn Edison Company, Brooklyn, N. Y. Since 1923 he has been electrical construction engineer and had the supervision of the electrical construction of the Hudson Avenue power station and of substations. Also from 1928 to 1930 he was chairman of the accident prevention committee of the engineering national section of the National Electric Light Association.

F. L. Aime (A'15) an electrical engineer for the J. G. White Management Corporation, New York, N. Y., and for many years identified with the Utility Management Corporation, New York, N. Y., recently joined the staff of the consulting engineers, Gibbs and Hill, also of New York. Specifically, his new operations will include assignment to high voltage cable work in connection with the electrification which his company has undertaken for the Pennsylvania Railroad.

A. J. Gowan (A'23) now has been engaged as electrical engineer of the U. S. Army Engineer Corps., Rock Island, Ill., in charge of electrical design and installation of locks and dams in connection with the Nine-Foot Channel development on a section of the Mississippi River. He has served as an electrical engineer with the General Electric Company, Stone and Webster Engineering Corporation, and Atmospheric Nitrogen Corporation.

W. C. Mainwaring (A'22) for the past fourteen years district sales manager of the Northern Electric Company, Limited, Vancouver, B.C., has been chosen to head the merchandising activities of the British Columbia Electric Railway Company, Limited, both on the mainland and on Vancouver Island. He will bear the title of merchandising manager, a new position created by the recent rapid expansion of this department.

R. W. Shoemaker (A'07, M'19) who was at one time electrical engineer and superintendent of the electrical department of the Turlock Irrigation District, California, and more recently engaged by the Electric Bond and Share Company at Rio de Janeiro, now after a two years' stay in Brazil has returned to California to resume professional practise.

N. L. Towle (A'20, M'24) who has been assistant professor in charge of electrical laboratories at Cooper Union, New York, N. Y., now has been given charge of that institute's department of electrical engineering, with the rank of full professor

Professor Towle who has been on the staff since 1920 previously taught in the Iowa State College at Ames, Ia.

O. H. CALDWELL (A'13, M'22) editor of "electronics" and "Radio Retailing," issued by the McGraw-Hill Publishing Company, New York, N. Y., and E. L. NELSON (A'20, M'26) radio development engineer at the Bell Telephone Laboratories, Incorporated, New York, N. Y., have been elected directors of the Institute of Radio Engineers to serve for the year 1932.

A. T. PERKINS (M'25) president and general manager of the People's Motor Bus Company recently was elected to a two-year term of service as a member of the board of directors of the St. Louis (Mo.) Chamber of Commerce. E. B. MEISSNER (A'16) president and general manager of the St. Louis Car Company, also has been elected a member of its executive committee.

A. G. RICHARDSON (A'24) who for two years was chief engineer of the Allen Hough Carryola Company, Milwaukee, Wis., and for a year after severing connections with that company, remained in Milwaukee to do experimental work for himself, using the Allen Hough laboratory, returned to New York, N. Y., December 1, 1931, to engage in radio service.

G. F. SANDERSON (A'30) who has been doing engineering work for the Metropolitan Edison Company, Reading, Pa., now has become general manager for the West-Lon Light and Power Company, the Allied Vermont Utilities Company, and the Weybridge Light and Power Company, subsidiaries of the Colonial Utilities Corporation, Chester, Vermont.

E. B. FREEMAN (A'21) vice-president and general manager of the B. F. Sturtevant Company, Hyde Park, Boston, Mass., has been elected president succeeding former Governor Eugene N. Foss, who has been made chairman of the board of directors. Mr. Freeman's rise in the organization was from the sales engineering department.

W. J. DUCEY (A'22, M'30) who was assistant electrical engineer for Allied Engineers, Inc., Jackson, Mich., now has been made the electrical engineer of Consumers Power Company at Jackson. Mr. Ducey is chairman of the overhead systems committee of the Great Lakes division of the National Electric Light Association.

S. S. GREEN (A'20) secretary-treasurer of the Duncan Electric Manufacturing Company, Lafayette, Ind., has been appointed chief engineer to succeed the late JESSE HARRIS (M'27). Mr. Green has been on the engineering staff of the company since 1929, when he first became identified with the Duncan organization.

G. J. NEWTON (A'10, M'15) who has been doing consulting work at Hollywood, Calif., now has removed to Youngstown, Ohio, to practise consulting distribution engineering there. Between 1916 and 1924 Mr. Newton served the Institute's power transmission and distribution committee for four terms.

R. D. MCMANIGAL (A'18) who has been serving the Westinghouse Electric Company of Japan at Tokyo as its special representative, now has been made assistant to the manager of the central station and transportation division of the Westinghouse Electric International Company, New York, N. Y.

SIDNEY HOSMER (A'97, F'12) who recently was made vice-president and assistant general manager of the Edison Electric Illuminating Company of Boston, Mass., now has been elected a director of the company to replace Robert Saltonstall, resigned.

R. E. DOANE (M'25) who until recently was manager of the price and cost department of the Standard Underground Cable Company division of the General Cable Corporation, now has become sales engineer of the Doane and Jones Company, at Elmira, N. Y.

A. A. LEEVEN (A'24, M'30) superintendent of the electrical engineering department of Cia Hidroelectric Guanajuatense, S. A., in Mexico City, Mexico, was appointed division engineer of Cia Nacional de Electricidad, S. A., Torreon, Coahuila, Mexico, effective April 1, 1932.

TERUYOSHI MATSUO (A'30) imperial inspector of the Japanese Navy, who has been in New York, N. Y., doing work for his government, now has returned to Japan, where he has been engaged in the capacity of electrical engineer for the Kure Kaigunkosyo Denki-Jikkenbu, at Hiroshima.

R. T. BAUSCHMAN (A'28) who was power sales engineer of the Pennsylvania Power and Light Company at Hazleton, Pa., recently was transferred to the statistical division, system operating department of that company.

M. W. KELLERMAN (A'29) formerly assistant general foreman of the Appalachian Electric Power Company at Welch, W. Va., now has been made rural extension engineer for the same company at Pulaski, Va.

W. S. ROLLO (A'25) who has been doing engineering service for the Otis Elevator Company's Yonkers (N. Y.) works recently became connected with an English company, the Waygood Works, Ltd., in London.

SAMUEL REBER (A'93, F'12, and a Member for Life) general foreign representative of the Radio Corporation of America, New York, N. Y., recently was elected a director of the American-Russian Chamber of Commerce.

EMERICK TOTH (A'29) has left the Kolster Radio Corporation, Newark, N. J., where he was a laboratory assistant, and is now receiver engineer on high frequency circuits for Wired Radio, Incorporated, of Ampere, N. J.

J. P. EDWARDS (A'92, M'13) recently retired from the office of Eastern division traffic superintendent of the Western Union Telegraph Company. His term of service covered a period of some twenty years.

C. D. TAYLOR (M'20) who has been manager of the refrigeration department of Westinghouse Electric and Manufacturing Company, Mansfield, Ohio, now is vice-president and general manager of The Elin Company, at Philadelphia, Pa.

C. B. O'NEIL (A'29) previously sales engineer for Fairbanks, Morse and Company, at Houston, Texas, now has been transferred to St. Louis, Mo., where he will be district manager of railroad sales for his company.

A. A. ARMER (A'27) development engineer for the Magnavox Company, Ltd., Berkeley, Calif., now has been appointed field engineer for this company. His headquarters will be at Fort Wayne, Indiana.

T. H. CHEN (A'29) who has been doing postgraduate student work at Cornell University, Ithaca, N. Y., now has returned to China where he will be identified with the Nanchang Electric Company, Nanchang, Kiangsi, China.

J. N. BARRETT (A'21) in the past sales engineer for the Otis Elevator Company in the Detroit, Mich., district, now has been transferred to the company's offices at Washington, D. C.

F. I. DEGEN (M'24) who has been practising engineering in New York, N. Y., now has been elected vice-president of the Babcock Manufacturing Company, Leonardsville, N. Y.

R. W. GASKINS (A'24) formerly serving the Stone and Webster Engineering Corporation as engineer, has removed from Boston to join the Troy Laundry Machinery Company, East Moline, Ill.

K. HIROSE (A'23) designing engineer for Shibaura Engineering Works, Kanasugi, Shibaku, Tokyo, Japan, now has been transferred by his company to Tsurumi, Yokohama City, Japan.

F. I. MORGAN (A'31) who has been with the Pennsylvania Water and Power Company at Holtwood, Pa., now has affiliated himself with the Safe Harbor Water Power Corporation at Safe Harbor, Pa.

E. A. MELLINGER (A'08) director of the Automatic Telephone and Telegraph Company, Chicago, Ill., recently resigned from his position on its board.

C. E. Chatfield (A'06, M'25) has resigned from the position of Chicago manager of the Lapp Insulator Company to form a sales agency at Indianapolis, Ind.

H. H. Hansson (A'29) electrical engineer for Sargent and Lundy, Inc., Chicago, Ill., now has engaged in like capacity with Motala Ström Kraft A. B., Motala, Sweden.

Obituary

Bernard Arthur Behrend (A'00, F'12) internationally noted as an engineer and for his inventive genius, met with sudden death March 25, 1932, at his home in Wellesley, Massachusetts. He was born in Villeneuve, Switzerland, May 9, 1875, and as a boy resided in Switzerland, England, and Germany, receiving his early education by private tutelage, and through a course in the Polytechnic Institute and University of Berlin, Germany, from which he was graduated in 1894 with a C.E. degree. During the year following he was assistant to the late Gisbert Kapp, and in 1896 he became assistant chief engineer to the Oerlikon Company, Switzerland. This was immediately prior to his coming to the United States. He at once applied for citizenship and was granted naturalization in 1903. He has been non-resident lecturer at the University of Wisconsin, Leland Stanford University, McGill, and Massachusetts Institute of Technology. In 1899 he connected with the Bullock Electric Manufacturing Company, Cincinnati, Ohio, as chief engineer of its a-c. work, this office being subsequently extended to include all of the company's plants in both the United States and Canada. In 1904 the Bullock Electric company became allied with the Allis-Chalmers Manufacturing Company, Mr. Behrend continuing in the office of chief engineer of electrical departments in this company; he also established the first department in Milwaukee for the production of large units. At the end of 1908 receivers of the Westinghouse Electric and Manufacturing Company engaged Mr. Behrend and members of his staff to take charge of the power engineering departments at East Pittsburgh, Pa.; here he remained for 18 years, although devoting a large portion of his time to consulting work in Boston, Mass. Mr. Behrend has always been a prolific contributor to technical literature; his first outstanding work, "Theory of the Induction Motor (Circle Diagram)" produced between 1894 and 1896, represented one of the earliest expositions on a theory now universally applied, and used today in practically the same form in which he gave it over 36 years ago. It was chiefly the subject of his university lectures, and was published later in book form under the title "The Induction Motor," translations appearing in French, German, and some sections, even in Japanese. In 1897 he developed the theory of the regulation of alternators under inductive loads, urging its adoption for purposes of standardization. This was adopted in general as first proposed by him, although sometimes known under the name of "Potier" method; a paper before the Institute described the method in detail and recommended its standardization. Among others of his contributions are many Institute papers. In 1902 Mr. Behrend introduced the radial-slot cylindrical turbo-generator rotor with chrome nickel end rings. This unit was exhibited jointly at the World's Fair in 1904 by the Bullock Company and Hoovens, Owen, and Rentschler; it won the grand prize and Mr. Behrend was the recipient of the accompanying gold medal. The largest power unit of the exposition was a 3,500-kw. generator driven by an Allis-Chalmers engine, a product of Mr. Behrend's inventive ability. Between 1900 and 1908 he designed the electric generating units for the Kern River Power Company, the Pacific Electric Company, the Denver Gas and Electric Company, a large group of the Niagara Falls units, the receiving plant of frequency changing units at Montreal linking the Shawinigan Water and Power Company with the power plants at Montreal, the steam turbine units of the Brooklyn Edison Company and the Brooklyn Rapid Transit Company (at that time the fastest of their type). The large gas engine driven units of the Carnegie Steel Company, the Illinois Steel Company, and of the Indiana Steel Company were all of his design. In 1909 he introduced the radial slot rotor to the Westinghouse company and developed the plate rotor construction now used by the company for its largest types of turbo-generator rotors. It was a revolutionary type devised for the purpose of overcoming defects in large forgings. While engaged with the Allis-Chalmers and Westinghouse companies, Mr. Behrend took out over 80 patents. Devoted to the interest of engineering education, he organized under A. G. Wessling the first engineering training classes at Cincinnati, Ohio. He has served on many technical committees, among them the Institute's standards committee, the U. S. national committee of the International Electrotechnical Commission, the Engineering Societies Library Board, and the Edison Medal committee; he was chairman of the Institute committee on professional conduct, and electrical machinery, and was first chairman of the A.I.E.E. Section in Cincinnati. His service as a manager and senior vice-president of the Institute was over a period of five years. In 1912, for improvements on high-speed electric generators, he received the John Scott Medal; he was a member of the A.S.M.E. and the A.S.C.E. and of the Franklin Institute; a fellow of the American Physical Society, the American Society for the Advancement of Science, and the American Academy of Arts and Sciences, and a member of the Engineers' Club of New York.

Charles Leavitt Edgar (A'96, F'12) president and general manager of the Edison Electric Illuminating Company of Boston, Mass., died of pneumonia April 14, 1932, at the Marlborough Blenheim Hotel, Atlantic City, N. J. Mr. Edgar, who was in his seventy-second year, was a native of Somerset County, New Jersey. He was graduated in 1882 from Rutgers College, New Brunswick, N. J., receiving at that time the two degrees of A.B. and A.M.; his honorary degree in E.E. was received subsequently for postgraduate work at the same institution. The year following his graduation he connected with the Edison Machine Works in New York, N. Y., for nine months; then was transferred to the factory of the Bergman Company, which manufactured central station apparatus. Shortly thereafter he became connected with the Edison Electric Light Company at its original factory in New York, N. Y. This service continued until 1887, by which time he had advanced to the position of chief engineer. Most of his work had been of a general engineering character with particular reference to the installation of small central stations throughout New York and adjoining states. In the fall of the year 1887 the parent Edison company sent Mr. Edgar to Boston as superintendent of the Edison Electric Illuminating Company of Boston, which had been organized the year before; in 1889 he became general manager and shortly thereafter vice-president; and upon the death of Jacob Rogers in 1900 he was chosen president. The central station industry in this country owes much of its pioneer work to Mr. Edgar who toiled with diligent devotion to make its influence far reaching. He has made numerous trips to Europe to study first hand the methods used in the largest electric plants there, and as a result of these investigations he was among the first to appreciate the value of storage batteries as central station auxiliaries; in fact it was he who imported from Germany the Tudor battery, the first to be used in this service in this country. He also foresaw the importance of compact generating units for stations in congested districts, and installed at Boston the first vertical engines used in America for central station work. On a special visit to England in 1898 he studied the Wright demand system of charging and upon his return introduced this into the service of the Boston company. One of the features that has contributed great success to this company is its highly developed welfare work; Mr. Edgar interested himself personally in the formation of the Edison Employees' Club which gave so much impetus to similarly organized groups and later, to company sections of the National Electric Light Association in other cities. The Boston club has served as a model for many others. After being three times vice-president of the National Electric Light Association he was elected its president in 1903. He has been president of the Massachusetts Electric Light Association, at one time was chairman of the A.I.E.E. Section in Boston, and has served the Institute on the Edison Medal committee. Always a keen student of sociology and political economy in connection with modern industry, of recent years he has devoted much of his time to the affairs of the National Civic Federation, serving as a member of its committee of twenty-four, investigating the question of municipal ownership of public utilities in other countries. He also was chairman of the industrial welfare department of the federation for several years, in which work

he made several surveys of the problem of old-age dependency and pensions. At the time of his death he was chairman of the board of the New England Power Association; a member of the executive committee of the Employers' Liability Assurance Corporation, Ltd.; director of the Employers' Fire Insurance Company of Boston, and of the Electrical Testing Laboratories of New York; and a trustee of the Massachusetts Utilities Associates Employers' Group Associates, and of Rutgers College, from which he received his Doctor of Science degree in 1927. He is a past-president of the Edison Pioneers and a member of Illuminating Engineering Society, The American Society of Mechanical Engineers, the Society for Electrical Development; also of the Exchange, Country, Algonquin, and University clubs of Boston, and the Engineers and University clubs of New York.

Francis M. Hartmann (A'02, F'14) dean of the school of engineering, Cooper Union Institute of Technology, New York, N. Y., and head of its electrical engineering department, died at his home March 28, 1932, as the result of complications which followed an operation. Dean Hartmann was born August 31, 1870, at Cochecton, New York. He attended Damascus Academy, in Pennsylvania, and New York evening high school. His B.S. degree was granted him upon the completion of a five-year course in general science at Cooper Union night school, New York, N. Y., in 1895; eight years later, by postgraduate work in physics and electrical engineering, he earned his E.E. degree. In the interim, however, he was graduated from a three-year course in chemical analysis, also taken at the Cooper Union night school, and had taken postgraduate work in physics and electrical engineering and other postgraduate work in mathematics at New York University. From 1891 to 1894 he was engaged in surveying and engineering with H. H. Spindler, for the City of New York, and from that time until 1901, Mr. Hartmann was computer in the city department of public improvement. Then he received his appointment as instructor in physics and electrical and mechanical engineering at Cooper Union for both day and night school, a position which he occupied until in 1905 he was made assistant professor of electrical and mechanical engineering, three years later to be placed in charge of the department. Paralleling a portion of this period he was working with A. G. Koenig, consulting engineer of New York; also with the E. E. Cary Company. In 1908 Cooper Union chose him chairman of the committee on promotion for three science courses; a five-year night school course in electrical engineering, a five-year night school course in general science and the day school technical science course. Dean Hartmann's contributions to technical literature have covered a variety of subjects. In 1912 he designed and equipped the new dynamo laboratories and thermodynamic laboratory for the Hewitt Memorial Building, Cooper Union. In addition to his membership in the Institute he was a Fellow of the American Association for the Advancement of Science, a member of The American Society of Mechanical Engineers, the American Physical Society, the American Mathematical Society, and the Society for the Promotion of Engineering Education.

D. A. Wadia (A'21) who for some time has been identified with the engineering branch of the Burma Shell Oil Storage and Distributing Company of India, Limited, St. Helen's Court, Ballard Estate, Fort Bombay, India, died at Surat on the 13th of January 1932. Of late he has been making his home with his uncle at Dadar. Mr. Wadia was a native of Bombay (1887); he held a scholarship from the Victoria Jubilee Technical Institute at Bombay, which allowed him to matriculate at the Bombay University. In 1908 he received the Victoria Jubilee Technical Institute first-class certificate with the degree of licensed mechanical engineer; he also held a certificate from the City and Guilds London Institute, department of technology, in the preliminary grade of electrical engineering, and a certificate for competency for what is there known as the Bombay Boiler Act, issued by the government. During his student days at the Victoria Jubilee Technical Institute, Mr. Wadia worked upon the erection of the institute's central power station, and prior to undertaking wiring installations for the Fazulbhoy Mills, Limited, he worked for eight months on a similar installation for D. R. Cooper and Company. As second assistant engineer, he joined the Brush Engineering Company of England, and was engaged by it in work upon the power house of the Bombay Electric Supply and Tramways Company. Another year was spent as electric foreman of the Simplex Conduits Limited. Engaged with the Tata Hydroelectric and Power Supply Company, Bombay, Mr. Wadia worked for three years upon the erection of substations. From 1914 to 1915 he was electrical supervisor for the Bombay Government Public Works Department, and for the next two years he was engaged with the Tata Hydroelectric Company as mill inspector in charge of electrically driven mills. In 1917 he entered the military works service at Karachi, assuming charge of all electrical and mechanical work in connection with machinery and shipments, erecting and maintaining the electrical installation connected with the Karachi concentration and rest camps. He also had charge of a 3-ton ice plant, both in its erection and maintenance.

Brace Hayden Hamilton (M'22) manager of the Washington, D. C., office of the Westinghouse Electric and Manufacturing Company, died March 21, 1932, in that city. He was born in Buffalo, N. Y., May 19, 1877, and after graduation from Cornell University with the class of 1899, he joined the General Electric Company for work on the design of d-c. and a-c. motors and generators. From 1902 to 1908 he specialized on turbo-generators and was involved in the supervision of special tools and methods essential to the construction of high speed apparatus. He also developed special designs and applications of governors and lubrication devices for turbines. Mr. Hamilton left the General Electric Company in 1909 to engage with the power division of the Westinghouse Electric and Manufacturing Co., Washington, D. C., on similar work in the design of d-c. and a-c. turbo-generators of the engine and water-wheel types. From 1910 to 1920 he worked on the design of power projects and the application of all types of power apparatus for the United States government, including the design of several complete plants. In 1917 he submitted a report to the chief of engineers, U.S.A., on the Potomac River hydroelectric development; this work was combined with laboratory experimental fixation of atmospheric nitrogen and with a study of an additional water supply for the District of Columbia. The year 1920 found him doing engineering work on generation and distribution of power from Wilson Dam, Muscle Shoals. For four years from 1917 to 1921, work on geared, electric and Diesel-electric marine drive, and auxiliaries for Navy vessels and the Merchant Marine occupied him; in fact as early in his career as when he was with the General Electric Company, Mr. Hamilton was responsible for the turbine design of horizontal turbo-generator sets for ships use.

Jesse Harris (M'27) who has been engineer in charge of development for the Duncan Electric Company, Lafayette, Ind., died February 15, 1932. He was born in Albany, N. Y., March 10, 1864; his schooling, the equivalent of a college education was supplemented by technical study. During the year 1888 he was engaged in general electrical contracting in Albany, and two years later entered the experimental department of the Thomson-Houston Electric Company at Lynn, Mass. In a year's time he had advanced to the position of assistant foreman of the meter department, thereafter becoming foreman of the instrument department. Returning to Albany, he was electrical engineer and superintendent of the Federal Instrument Company, and later electrical engineer of the Dongan Instrument Company. In 1907 he went to Lafayette, Ind., to develop recording instruments for the Central Laboratory Supply Company and the following year he joined the Duncan Electric Company, with which he remained for ten years as superintendent and fifteen years as chief development engineer on a-c. and d-c. meter development. Mr. Harris held twenty or more patents on various metering devices. one on a synchronous induction motor and another on a special system for operating a-c. motors from d-c. sources. He was considered a master technician in his line and did much excellent work in the correction of temperature errors in watthour meters. While with the Duncan company he was responsible for most of its design and development work.

Thomas Foulkes (A'08, M'13) founder of the Foulkes Electrical Company, Los Angeles, Calif., and a man who accom-

plished much of the pioneer work of the West in electrical engineering, died March 14, 1932, at the age of 80. He was born in England, receiving his early education in the common schools and partly at night school. He started his electrical work in the early days of the industry with the Citizens Electric Light Company, at Helena, Montana; then he spent a year with the Edison Company at Tacoma, Washington, a year with the Thomson-Houston Company, at Portland, working on the installation of isolated plants, and afterward some time with the General Electric Company. He was manager of the Baker City Electrical Light Company, Ore., engineer of the Hill House Hotel at Tacoma, Wash., and chief engineer of the Portland Hotel at Portland, Ore. He later went to southern California where in 1894 he became chief engineer of the municipal electrical plant at Pasadena. Two years later he bought an electrical business in that city, and in 1897 opened an electrical supply business in Los Angeles with a factory at Naud Junction. The factory was discontinued in 1899, and from then on the activities of the Foulkes Electrical Company were devoted exclusively to electrical engineering, design, and installation. Mr Foulkes was the first president of the Los Angeles board of public utilities.

Max Neuber (A'08, M'31) experimental engineer of the Moto Meter Gauge and Equipment Company, Toledo, Ohio, and secretary-treasurer of the Institute's Toledo Section, died April 4, 1932, at his home in that city. Mr. Neuber was born in Leipzig, Germany, and came to this country in 1889, his education including two years' schooling in Germany and six years in the public schools of Toledo, Ohio. He started to work in the factory in which his father was machinist, attending night school at the Toledo manual training school; he took up mechanical drawing and machine work also. This was followed by a correspondence course in mechanical and electrical engineering. By the time he had been in business eleven years he was operating machine works which involved a number of his own inventions, including an electric button machine and a water filtration system. Mr. Neuber leaves behind him a record of loyal service to the A.I.E.E. Section of which he was an officer, as well as an appreciation of the spirit of fellowship with which he inspired his many friends.

Marvin C. Ansteth (A'30) assistant superintendent of the western division of the Niagara, Lockport, and Ontario Power Company, Lockport, N. Y., died April 1, 1932 at Lockport. He was 36 years old and was born in Buffalo, N. Y., where he passed through elementary school and three years of technical high school. In 1915 he engaged with the Westinghouse Electric and Manufacturing Company at Buffalo, and two years later joined the Niagara, Lockport and Ontario Power Company as assistant superintendent of its Lockport-Mortimer districts. His affiliation with this company represented an uninterrupted period of service.

Local Meetings

Student Convention at Haverford College

The eighth annual local student convention sponsored by the Philadelphia and Lehigh Valley Sections was held at Haverford College on March 14, 1923, with eight schools participating: namely, Delaware, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore. The program of the morning session was as follows:

Thyrite Lightning Arresters, by Albert Werner, Drexel Inst.

Ship Stabilizing Devices, by W. J. Henderson, Jr., Univ. of Pa.

Solving Polyphase Problems by Symmetrical Components, by W. M. Dudley, Swarthmore Col.

Electricity in Aviation, by L. F. Underwood, Lehigh Univ.

Those attending the convention were guests of Haverford College at luncheon, afterward separating into groups, according to preference, to visit the Plymouth Meeting substation of the Philadelphia Elec. Co., high speed electric railway of the Philadelphia & Western RR. Co., Wayne Junction substation, Bell Telephone Co., and RCA Victor Co. Following dinner at the Engineers Club, Dr. W. E. Wickenden, president, Case School of Applied Science, gave an address entitled "The Engineer's Professional Status." The registration was 150.

Future Section Meetings

Akron

May 10—Annual banquet and ladies' night. Human Engineering, by Dean Fred E. Ayer, Univ. of Akron. Movies.

Baltimore

May 20—Speaker: Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E.

Cleveland

May 19—Subject and speaker to be announced.

Detroit-Ann Arbor

May 17—House of Magic, by Oliver Ajer, Genl. Elec. Co.

June 21—Spring frolic.

Lehigh Valley

May 13—High Voltage Cables, by D. M. Simmons, Genl. Cable Corp. Meeting to be held at Americus Hotel, Allentown, preceded by dinner.

Louisville

May 13—Dial Telephone Equipment in Louisville. Speaker from the Southern Bell Tel. & Tel. Co.

June 3—Recreation meeting.

Pittsburgh

May 10—Annual banquet and ladies' night.

Seattle

May 17—Address by L. Sapovi, Hooker Electro-Chem. Co.

Spokane

May 27—Annual dinner meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

Vancouver

May 21—Annual outing to the Baker River Plant of the Puget Sound Pwr. & Lt. Co.

June 6—Annual dinner.

Past Section Meetings

Baltimore

Some Features of Interest in Motor Driven Water Pumping Stations, by Leon Small, water engr., City of Baltimore. Dinner. Feb. 19. Att. 74.

The Naval Engineering Experiment Station, by Capt. H. R. Greenlee, director. Inspection trip through the naval station. March 18. Att. 72.

Boston

The Osage River Development, by A. A, Northrop, H. B. Wood, H. O. Murphy, all of Stone & Webster Engg. Corp. Motion pictures. Feb. 16. Att. 205.

Short Time Phenomena With Relation to Recent Developments in Circuit Interruption, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. Films—"Pole-Pushers in Puget Sound" and "The Magic of Communication." March 8. Att. 165.

Chicago

The Electrical Industry of Today, by C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with Western Soc. of Engrs. March 25. Att. 108.

Cincinnati

Steel Research in Electrical Manufacturing, by J. Fletcher Harper, Allis-Chalmers Co. Dinner. March 10. Att. 60.

Electrons at Work and Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with Engrs. Club of Dayton. April 7. Att. 300.

Cleveland

Non-destructive Magnetic Testing of Ferrous Materials, by J. Kacmarik, Jr., student; The Practical Significance of Dielectric Power Factor, by R. W. Schindler, student; Ether Drift and Relativity, by Dr. Daynton C. Miller. Joint meeting with Case Sch. of App. Science Branch. March 24. Att. 199.

Columbus

Engineering in the Foreign Field, by H. W. Bibber, Ohio State Univ. Joint meeting with Engrs. Club of Columbus. March 18. Att. 39.

Connecticut

Air Conditioning, by E. D. Milener, Am. Gas Assn., and W. K. Keplinger, Carrier Engg. Corp. March 15. Att. 150.

Dallas

Underground Construction and Cable Development, H. K. Doyle, Dallas Pwr. & Lt. Co. March 21. Att. 78.

Detroit-Ann Arbor

Vacuum Tubes and Their Application, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. Joint meeting with I.R.E. March 15. Att. 450.

Denver

Electric Steel, by J. E. Holtman and J. H. Spillane, Am. Manganese Steel Co. Dinner. March 18. Att. 34.

Erie

The X-ray in Industry, by E. W. Page, Genl. Elec. X-ray Corp. March 15. Att. 85.

Fort Wayne

The Industrial Applications of Vacuum Tubes, by L. A. Hawkins, Genl. Elec. Co. March 3. Att. 95.

Houston

High Pressure Steam System at Deepwater, by H. G. Hiebler, Houston Lighting & Pwr. Co. Inspection of the plant. March 18. Att. 84.

Iowa

E. O. Schreve, Genl. Elec. Co., reviewed recent advances made in the development of new products and the improvements in design and manufacture of existing apparatus. Joint meeting with Iowa State Col. Branch. March 1. Att. 58.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., assist. director of engg., Westinghouse Elec. & Mfg. Co. March 23. Att. 30.

Kansas City

The World of Electronics, by L. A. Hawkins, Gen. Elec. Co. Joint meeting with Engg. Societies of Kansas City. Feb. 29. Att. 810.

Surge Proof Transformers, by H. V. Putman, Westinghouse Elec. & Mfg. Co. March 18. Att. 65.

Los Angeles

Annual Student meeting under the auspices of the Calif. Inst. of Tech. and the Univ. of Southern Calif. Branches. Some Phases of Institute Work, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E.; Electrical Dehydration, by M. S. Hodge, student, C. I. T.; Study of Pasadena Distribution, by A. Butler, L. J. Wright, E. G. Olinstud, and D. E. Batchelder, students, C. I. T.; Retardation Method of Testing Rotating Machinery, by W. W. Austin, student, U. S. C.; Mathematical Analysis of Retardation Method, by G. R. Little, student, U. S. C. Dinner. March 8. Att. 106.

Louisville

The following papers presented by students of the Univ. of Louisville: The Life of Steinmetz, by C. D. Eldridge; The Life of Marconi, by K. A. Dick; The Life of Faraday, by W. G. H. Stafford; Theory of Operation of the Thyratron Tube, by P. Frank; Electrical Eye by Mr. Best. Motion pictures and demonstrations. March 18. Att. 66.

Lynn

Miracles in Nature, by A. C. Pillsbury. Demonstrations. March 9. Att. 1200.

The Comparison of Radio Frequencies, by R. S. Davidson; Some Physical Characteristics of Parts Molded From Phenolic and Resinous Compounds, by A. White; Significance of Noise Measurements, by K. H. Pratt; Mechanical Effects of Overcurrent Current Transformers, by A. T. Sinks, all of the Genl. Elec. Co. March 23. Att. 300.

Madison

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. March 18. Att. 57.

Memphis

Film—"All Steel Electric Welded Houses." March 8. Att. 30.

Milwaukee

A Modern Large Electrical Shovel, by P. S. Stevens, Bucyrus-Erie Co. Moving pictures. Feb. 10. Att. 65.

Space Cooling With Ice, by A. J. Authenrieth. Middle West Utilities Corp. Feb. 17. Att. 250.

Minnesota

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner. March 21. Att. 75.

Niagara Frontier

High Spots in the Design of Steam Electric Power Plants, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. Dinner. March 10. Att. 55.

Oklahoma City

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 29. Att. 115.

Portland

The Trend in Power Plant Development, by W. F. Hynes, Genl. Elec. Co. March 15. Att. 76.

Providence

Vertical Transportation, by A. S. Noyes, Otis Elev. Co. Dinner. March 8. Att. 40.

St. Louis

Surge-Proof Transformers, by H. V. Putman, Westinghouse Elec. & Mfg. Co. March 16. Att. 96.

San Antonio

Installation and Operation of Electrical Equipment on Battleships, by E. M. See, Genl. Elec. Co. March 28. Att. 18. San Francisco.

San Francisco

Principles of Flight and Recent Developments in Aeronautics, by Prof. E. G. Reed, Stanford Univ. March 25. Att. 68.

Seattle

Overseas Telephone Service of the Bell System, by W. H. Harrison, Am. Tel. & Tel. Co. Joint meeting with I.R.E. Feb. 19. Att. 250.

Timber Utilization, by C. W. Hogue, West Coast Lumberman's Association; Forestation, by Dean H. Winkenwerder, Univ. of Wash. Joint meeting with A.I.M.E., A.S.C.E., and A.S.M.E. Sections. March 21. Att. 115.

Sharon

The Expanding Universe, by F. C. Jordan, director, Allegheny Observatory. March 22. Att. 300.

Southern Virginia

Joint meeting with A.S.C.E. and A.S.M.E. Sections, and Engrs.' Club of Hampton Roads. Friday morning, Cecil Gray, chmn., So. Va. Section, A.I.E.E., presiding: History of Sound Pictures, by J. R. McLemroe, Electrical Research Products, Inc. Business meetings. Luncheon, W. P. Tunstall, pres. Engrs.' Club of Hampton Roads, presiding: Welcome address by C. B. Borland, director of Public Safety, City of Norfolk; More Landmarks for the Seafarer, by Lieut. E. B. Roberts, U. S. Coast and Geodetic Survey; News, by W. R. Harris, Norfolk Virginian-Pilot. Friday afternoon, Motor bus trip to Great Bridge, Va. Friday evening, dinner, Prof. A. F. Macconachie, Univ. of Va., presiding: E. M. Hastings, A.S.C.E., toastmaster, Water Purification and Its Relation to the Public Health, by Prof. J. H. Gregory, Johns Hopkins Univ.; Human Engineering, by G. Guy Via, Newport News Shipbuilding and Dry Dock Co. Saturday, Golf and visits to places of interest in the vicinity. March 25–26.

Spokane

Some Developments in Talking Pictures, by K. P. Kenworthy, student; The Calibration of a Dynatron Oscillator From Broadcast Harmonics, by M. Herr, student; Power System Frequency Control, by C. Cannon, student. Joint meeting with Univ. of Idaho and Wash. St. Col. branches. March 25. Att. 60.

Springfield

Development and Application of Photoelectric Cell, by A. R. Olpin, Bell Telephone Co. Jan. 11. Att. 122.

Television—Its Fundamental, Physical, and Psychological Principles, by J. O. Perrine, Am. Tel. & Tel. Co. Feb. 8. Att. 650.

Toledo

Inspection trip through the Rossford plant of the Libbey Owens Ford Glass Co. March 22. Att. 300.

Toronto

The Elevator or Vertical Transportation, by E. J. Ellis, Otis Fensome Elev. Co. Illus. March 11. Att. 59.

Electrical Features of New Plants, Mining and Smelting Division, by W. E. Gillespie, Intl. Nickel Co. April 8. Att. 57.

Vancouver

Carrier Current Telephony, by H. M. Van Allen, student; The Thyratron Tube, by J. W. McRae, student; Dust Precipitation by Electricity, by J. D. Mitchell, student. Joint meeting with Univ. of British Columbia Branch. March 7. Att. 57.

Washington

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Film—"Dynamic America." March 8. Att. 75.

Past Branch Meetings

Alabama Polytechnic Institute

Locating Interference in Radio Receiving Sets, by Prof. J. C. McKinnon; Keeping the Right-of-Way Clear for Power Lines, by R. P. Lapsley, student. March 10. Att. 19.

History and Development of the Clock, by T. Fullau. March 24. Att. 18.

Election of officers: R. W. Wages, chmn.; C. W. Stickler, vice-chmn.; J. W. Solomon, secy.-treas. March 31. Att. 25.

University of Alabama

Audible Light, by J. B. Taylor, Genl. Elec. Co. Feb. 20. Att. 1200.

Discussion. March 14. Att. 12.

University of Arizona

History, Purposes, and Characteristics of the A.I.E.E., by Prof. J. C. Clark, counselor. Election of officers: P. F. Hawley, chmn.; B. Watkins, vice-chmn.; J. Jones, secy.-treas. Feb. 5. Att. 7.

Steinmetz, by Bruce Watkins, student. Feb. 12. Att. 6.

Faraday, by H. E. Stewart, student. Feb. 19. Att. 7.

Westinghouse, by J. Jones, student. Feb. 26. Att. 6.

Lamme, by R. H. Carson, student. March 4. Att. 9.

Discussion. March 11. Att. 8.

Diesel Engine Generating Plant of the Tucson Gas, Electric Light and Power Co., by Bruce Watkins, student. March 18. Att. 7.

University of Arkansas

Outdoor Lighting, by W. C. Warram, student; Amplifiers, by H. D. Albrecht, student. March 7. Att. 24.

Harmonic Analysis, by J. H. Nelson, student; Photoelectric Cells, by L. Williams, student; Commutation, by J. A. Hays, student. March 21. Att. 25.

Radio Beacons, by N. F. Bolling, student; the Permeameter, by G. G. Farris, student; Mercury Arc Lamp, by J. C. Howard; Rural Electrification, by Mr. Robinson, student; Iron Losses, by L. Hildebrand, student. April 4. Att. 24.

Armour Institute of Technology

Development of Underground Power Cables and Their Use by the Commonwealth Edison Co., by Herman Halperin, Commonwealth Edison Co. March 4. Att. 40.

Automatic Elevator Control, by L. O. Sinderson, Genl. Elec. Co. Joint meeting with A.S.M.E. Branch. March 18. Att. 33.

Generating Stations of the Edison Company, by E. Peterson, Commonwealth Edison Co. April 1. Att. 40.

University of British Columbia

Election of officers: J. W. McRae, chmn.; H. C. Freedman, sec'y. March 23. Att. 19.

Brooklyn Polytechnic Institute

Communication With Quasi Optical Waves, by L. DeRosa, student; Electro-Anesthesia, by A. Cross, student; The Barkhausen Effect, by H. Beckman, student; Frequency Control by Use of a Thyratron Tube, by R. Buehl, student. March 16. Att. 43.

Constant Current Transformer, by V. D'Agostino, student; Repairing a Submarine Cable, by H. Hoffman, student; The Life of Steinmetz, by L. Higgins, student. March 23. Att. 49.

Bucknell University

J. M. Dobbie elected chairman. March 11. Att. 12.

University of California

The Use of Telephone Circuits in the Transmission of Radio Programs, by I. B. Cave, Pac. Tel. & Tel. Co.; Pressure Phenomena in Oil Circuit Breakers, by E. Atkinson, student. March 10. Att. 35.

The Development of the Pit River by the Pacific Gas & Electric Co., by E. A. Crellin, Pac. Gas & Elec. Co. March 24. Att. 28.

Carnegie Institute of Technology

The Electrical Engineering Graduate, by A. M. Dudley, Westinghouse Elec. & Mfg. Co. March 9. Att. 17.

Case School of Applied Science

Non-destructive Magnetic Testing, by J. Kacmarik, Jr., student; The Practical Significance of Dielectric Power Factor, by R. W. Schindler, student; Ether Drift and Relativity, by Dr. D. C. Miller. Joint meeting with Cleveland Sec. March 24. Att. 180.

Clarkson College of Technology

Demonstrations. March 1. Att. 71.
Demonstrations. March 7. Att. 52.

University of Colorado

How Radio Has Affected Modern Property Relations, by Dean Stearns, Univ. of Col. Law Sch. March 9. Att. 30.

Cooper Union

Inspection tour of the East River Generating Station of the N. Y. Edison Co. February 15. Att. 12.

University of Denver

Advantages of the G. E. Test Course for Graduate Engineers, by M. M. Boring, Genl. Elec. Co. March 8. Att. 36.

University of Detroit

The Talking Movies, by C. L. Strong, Elec. Research Prod., Inc. Demonstrations. April 6. Att. 55.

University of Florida

The Correlation of Solar Disturbances With Radio Transmission, by J. L. Wolcott, student. March 23. Att. 17.

Films—"I See You Calling Me" and "Pictures by Wire." April 4. Att. 38.

Georgia School of Technology

Problems Encountered in Network Broadcasting, by J. W. Hutchinson, Am. Tel. & Tel. Co. March 22. Att. 63.

Harvard University

Arc Welding, by Prof. C. A. Adams. March 16. Att. 31.

Inspection trip to the L Street plant of the Edison Elec. Ill. Co. of Boston. March 29. Att. 12.

University of Illinois

Problems in the Operation of Distribution Systems, by L. Shapiro, Central Ill. Pwr. & Lt. Co. March 9. Att. 40.

University of Iowa

Advance in the Art of Steam Generation of Electric Power, by J. M. Drabelle, Iowa Ry. & Lt. Co. March 2. Att. 39.

Photoelectric Cell, by D. E. Duckett, student; Pilot Wire Transmission Regulating Systems, by W. C. Davie, student; Some Experiments Performed on Lightning, by P. A. Colony, student. March 9. Att. 36.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., and asst. direc. of engg., Westinghouse Elec. & Mfg. Co. March 22. Att. 166.

The Present Practises in the Installation of Power Cables, by W. H. Carl, student; Injuries From Surge Discharges, by J. B. Cutler, student; The Cascade Tunnel, by W. A. Benincosa, student; Telephone Repeater Stations, by A. O. Behnke, student. March 30. Att. 37.

Kansas State College

The Recent Supreme Court Decision and the Kansas Public Utility Commission, by Prof. R. G. Kloeffler, counselor; Electric Clocks, by Mr. Elwell, student. March 10. Att. 34. Program repeated same evening. Att. 34.

University of Kansas

Automatic Substations, by Prof. R. W. Warner; Crystals and Characteristics of Crystal Control Circuits, by E. Kelley, student. March 17. Att. 39.

Lafayette College

Frank H. Welsh elected chairman. March 11. Att. 25.

Short Wave Radio Stations, by C. Markley, student. March 17. Att. 20.

Lehigh University

Electrical Aids to Aviation, by L. F. Underwood, student; Engineering Education for Civic Usefulness, by O. W. Eshbach, Am. Tel. & Tel. Co. Illus. March 11. Att. 70.

Lewis Institute

A-C. Low Voltage Network Systems, by O. J. DeBever, student. March 3. Att. 30.

Power Development in the Chicago Area, by W. S. Monroe, Sargent & Lundy Co. March 18. Att. 175.

University of Louisville

Faraday, by W. H. Stafford, student; Marconi, by Mr. Sutt, student; Steinmetz, by Mr. Eldredge, student. March 14. Att. 21.

Massachusetts Institute of Technology

Modern Uses of Electricity in Medicine, by E. W. Schafer, student. March 15. Att. 60.

Inspection trip through the Bowdoin Square exchange of the New England Tel. & Tel. Co. March 23. Att. 25.

Vertical Transportation, by H. S. Duncan, student. Dinner. March 30. Att. 35.

Michigan College of Mining and Technology

Electricity in the Army, by C. W. Ball. Prof. G. W. Swenson, counselor, gave a report of the A.I.E.E. winter convention held in New York. March 3. Att. 20.

University of Michigan

The Place of Organized Research in Modern Industry, by R. Foulkrod, Michigan Bell Tel. Co. March 3. Att. 60.

Radio Experiences With Garwood, by E. B. Etchells, student. March 24. Att. 10.

Films—"Automatic Arc Welding," "Automatic Substations" and "The Greater Campus." April 5. Att. 40.

Milwaukee School of Engineering

Progress Made in Communication to Automobiles by Radio, by H. Wareing, Milwaukee Police Dept. March 9. Att. 94.

Missouri School of Mines and Metallurgy

Motion pictures. March 9. Att. 13.
Exhibits. March 18. Att. 150.

Dynamometer, by Joseph Worley, Emerson Elec. Co. April 1. Att. 25.

Montana State College

A New Oscillator for Broadcast Frequencies, by Carl Wall; Means of Photographing Oscillograms, by R. Wells; Reducing Transmission Line Radio Interference, by R. Wyman; Transmission and Lighting Studies, by H. Bowman; Electricity From the Sun, by J. Cromer; Two Way Television, by T. Degenhart; all students. Feb. 11. Att. 94.

Electrification of Steam Railroads, by P. Alfers; Safety in the Air, by L. Eisele; Electrified Ice Plant, by C. L. Grebe; Teletypewriter Service, by M. Hilden; Floating Motor Drive Base, by G. Huizings; Achievements in Electrical Engineering in 1931, by J. D. Mathews; A Floating Electric Power Plant, by G. Misevic; Photoelectric Control, by J. Norlin; all students. Feb. 18. Att. 95.

University of Nebraska

Airships and the U.S.S. Akron, by V. R. Jacobs, Goodyear Zeppelin Corp. Motion pictures. March 23. Att. 175.

Newark College of Engineering

Carrier Currents, by C. H. Stephan, student; Electrically Driven Ships, by W. Arnott, student; Mercury Arc Rectification, by J. Hoerter, student. March 14. Att. 24.

Telemetering, by W. DeRitter, student; Synchronous Reproduction of Sound, by W. H. Gaeckler, student; X-rays, by H. Dorhmann, student. March 28. Att. 16.

College of the City of New York

Vacuum Tube Applications, by W. C. White, Genl. Elec. Co. March 10. Att. 150.

Oil-Electric Locomotives, by Mr. Garrison, Ingersoll Rand Co. March 17. Att. 34.

Power House Design, by Mr. Warren, Genl. Elec. Co. Illus. March 24. Att. 27.

North Carolina State College

Broadcasting, by H. K. Carpenter, mgr. radio station WPTF. March 1. Att. 30.

University of North Dakota

Discussion and motion pictures. March 16. Att. 12.

Electric Arc Welding, by R. D. Florance, student; Remote Wattmeter Reading, by D. F. Field, student. March 30. Att. 16.

Northeastern University

Engineering in Japan and Korea, by Prof. A. E. Kennelly, Harvard Univ. Refreshments. March 23. Att. 76.

Ohio State University

Election of officers: Len Winkler, chmn.; Charles McCarty, secy.-treas. March 10. Att. 25.

Oklahoma A. & M. College

Noise Induction Demonstrations, by C. E. Bathe, Okla. Gas & Elec. Co. and E. B. Jennings, Southwestern Bell Tel. Co. Feb. 1. Att. 14.

Experiences Since Leaving College, by Mr. Bonar, supt. of power plant on college campus. Feb. 29. Att. 20.

Battleships—Their Construction and Special Features, by G. W. Whiteside. March 14. Att. 25.

Oregon State College

Safety Education of Engineering Students, by Walter Smith, Mountain States Pwr. Co., First Aid in Industry, by F. P. White, Mountain States Pwr. Co. Feb. 25. Att. 28.

Pennsylvania State College

The Klydonograph and Its Use in Measuring Lighting Surges, by C. E. Laedlin, R. J. Maynard, and J. W. Hostetter, students; Study of Commutator Ripples and Their Effects, by R. Carlson and D. H. Smith, students. March 18. Att. 44.

University of Pittsburgh

Recent Developments in Science, by L. Colton, student. March 3. Att. 122.

Economics of Electrification, by Dr. Fitzgerald, Western Maryland R.R. March 10. Att. 116.

Musical program. March 17. Att. 120.

Alternating Current Electrification of Railroads, by H. M. Blackburn, student. March 31. Att. 124.

Pratt Institute

Gyro-Stabilizers, by G. H. James, student. March 17. Att. 62.

Employment of Pratt Graduates, by H. P. Miller, instructor. March 31. Att. 75.

Rensselaer Polytechnic Institute

Recent Developments in Oscillographs, by A. D. McAffer, Genl. Elec. Co. Demonstrations. Feb. 23. Att. 40.

Rhode Island State College

Growth of the Electrical Industry, by Prof. A. E. Watson, Brown Univ. March 3. Att. 21.

Photoelectric Cell, by J. F. Schmidt, student; Experiments Performed on the Banking of Transformers, by G. E. Andrews, Jr. and E. H Long, students. March 17. Att. 18.

Business meeting. March 31. Att. 9.

Election of officers: L. M. Lang, chmn.; J. P. Costanza, vice-chmn.; W. J. Daly, secy.-treas. April 7. Att. 12.

Rice Institute

Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co., outlined the present status of the electrical engineering field. Dinner. Feb. 24. Att. 43.

Problems Encountered in Constructing a Television Transmitter, by F. Kennedy, student. March 9. Att. 22.

Rutgers University

Harmonic Analysis Via Fourier Series, by F. P. Fisher, student. March 8. Att. 15.

The Theory of Magnetization and Related Phenomena, by C. I. Bradford, student. March 15. Att. 15.

University of South Carolina

The Engineer's Job in Times of Economic Depression, by C. H. Moorefield. Joint meeting with A.S.C.E. Branch. March 17. Att. 101.

Coordination of Light and Music, by W. J. Valentine, student; Is the Steam Train Engine Doomed? by W. G. Shannon, student; Electronic Equipment in Train Control, by A. G. Daniels, student; Life and Works of W. S. Lee, by G. W. Arrants, student. March 23. Att. 31.

Methods of Welding, by J. R. Hopkins, student; Corona Losses, by W. V. Farnum, student; Seeing the World With a Flying Camera, by T. K. Swygert, student; Cable Sheath Corrosion in Underground Conduits, by C. L. Bradley, student. March 30. Att. 36.

Business meeting. April 7. Att. 14.

South Dakota State School of Mines

H. L. Fry elected chairman. March 23. Att. 32.

Inspection trip through the Homestake mine. March 28–29. Att. 36.

University of Southern California

Theatrical Illumination, by L. O. Nauman, Otto K. Olsen Elec. Co. Feb. 17. Att. 31.

Thermionic Vacuum Tubes and Their Application to Industry, by W. A. Grimes, Westinghouse Elec. & Mfg. Co. Feb. 24. Att. 25.

Discussion. March 2. Att. 18.

Stevens Institute of Technology

Modern Developments in Organic Chemistry, by Prof. F. J. Pond. Luncheon. March 15. Att. 38.

Syracuse University

Protective Relays, by L. M. Kenan, student; Lightning, by F. J. Conklin, student. March 4. Att. 21.

Sound Detection in Water, by H. Francis, student; Demonstration of Television Apparatus, by P. Magee, student; Electrical Power Consumption During Depression, by F. T. Burroughs, student. March 18. Att. 21.

The Jet Rectifier, by A. B. Rowley, student; Demonstration of Ability of Insulation to Withstand High Voltage, by M. E. Hogan, student. March 25. Att. 21.

University of Tennessee

Pyrometry, by P. M. Bell, student. Jan. 28. Att. 36.

Electric Eye, by C. McCord, student. Feb. 11. Att. 47.

Audible Light, by J. B. Taylor, Genl. Elec. Co. March 11. Att. 410.

Texas A. & M. College

Power Rates, by J. H. Johnson, student. March 10. Att. 20.

Electrical and Industrial Development of Southwest Texas, by I. Uhr, Genl. Elec. Co. March 24. Att. 85.

Texas Technological College

Railway Electrification, by T. Haymes, student; Engineering as Related to American Industry, by H. Gray, student; The Life of Michael Faraday, by J. P. Conner, student. March 23. Att. 20.

The Financial Structure of a Utility Company, by H. D. Woods, Texas Utilities Co. April 6. Att. 26.

University of Utah

Effective Illumination, by L. B. Gawan, Utah Pwr. & Lt. Co., assisted by C. L. Ellerbeck of the same company. March 4. Att. 103.

University of Vermont

Prof. Buchanan outlined the uses of the oscillograph in detecting disturbances in power systems. March 7. Att. 16.

The Use of the Inverter in Power Transmission, by G. W. Patterson, student. March 21. Att. 16.

Virginia Military Institute

The Evolution of the Dial Telephone, by T. H. Harrel, student; The Development of the Telephone, by J. S. Lay, student; The Measurement of Frequency, by G. S. Bernard, student; The Development and Use of the Photoelectric Cell, by H. L. Woodson, student. Feb. 27. Att. 72.

Virginia Polytechnic Institute

Three Power Locomotives, by W. P. Swartz, student; Development of Electrical Power at the Conowingo Power Plant, by R. B. Poque, student; New Telephone Cable, by E. W. Seay, student; Thomas A. Edison As a Man, by N. C. Smoot, student. April 7. Att. 24.

Washington State College

Dean H. V. Carpenter, vice-pres. A.I.E.E., presented a report of the A.I.E.E. winter convention held in New York. March 11. Att. 17.

Water Power Frequency Control, by C. Cannon, student; Talking Picture Development, by K. P. Kenworthy, student; The Calibrations of the Dynatron Oscillator, by M. Herr, student. Joint meeting with Spokane Sec. and Univ. of Idaho Branch. March 25. Att. 57.

Washington University

H. Van Bodelschwingh described the educational system used in Germany. Feb. 18. Att. 35.

Discussion. Feb. 26. Att. 70.

West Virginia University

Westinghouse Electric & Mfg. Co., by E. D. Harris; Colfax Power Plant, by O. B. Spangler; The Mesta Machine Co., by L. Palmer; Carnegie Steel Co., by C. E. Higgins; Development of the Steam Turbine, by F. Q. Brown; Carnegie Steel Co., by G. E. Hervey; Powdered Fuels and Ash Precipitation, by C. B. Withers; all students. April 5. Att. 29.

University of Wyoming

A Study of Filter and Rectifier Assembly, by F. Wickenkamp, student. March 29. Att. 9.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Design and Development

ENGR., 31, 12 yr. Bell System, government plant and field experience on sound picture, radio and telephone (manual, dial, repeater, and carrier current) systems. Design and development of manual and automatic elec. testing equip. Industrail applications of electron tubes. Available immediately. C-9376.

E.E. GRAD., 28, married, desires position in design and development or teaching. One yr. Westinghouse student course; 6 months' Westinghouse design school; 1½ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC. DESIGNER-ENGR., 27, single, 8 yr. experience in design of complete elec. systems including equip., signals, lighting, elevators, telephone, and miscellaneous secondary systems for New York high office bldg. Writing elec. and elevator specifications. Responsible, capable asst. to engr. Desires position with consulting engr. firm. Available at once. D-586.

E.E., tech. grad., 10 yr. experience d-c. substation design. Thorough knowledge of mercury arc rectifiers and rectifier substations, expert draftsman, knowledge of radio, inventor. Available immediately. East preferred. B-7332.

E.E. GRAD., 37, single, citizen, desires position with engg., mfg., or utility. 6½ yr. in pwr. plant and substation design. 2 yr. elec. furnaces. G.E. engg. courses. Available on short notice. C-2710.

DESIGN ENGR., col. grad., 38, married, citizen; 15 yr. engg. experience including 6 yr. generating plant and substation design, and 3 yr. field experience as tester and supervisor. Desires position with utility, engg., or construction firm. Available immediately. Location, immaterial. D-482.

Executives

E.E. GRAD., 41, married, E.E., A.M., 12 yr. experience test dept. of large utility. 11 yr. teaching experience in evening engg. schools; 3 yr. design and manufacture of off-peak elec. storage type water heaters; analysis of load curves with a view of improving load factors. Location, immaterial. D-575.

E.E. GRAD., M.I.T., 35, married, 10 yr. experience Gen. Elec. Co. design and development of elec. measuring devices, desires position with holding company, utility or mfg. concern involving exec. and engg. ability. Immediately available. D-607.

E.E. GRAD., married, 36, 12 yr. experience in operation of elec. stations load dispatching and maintenance work. Would like position with utility company on station operating or system operation. D-611.

GRAD. E.E., 50, married, 25 yr. elec. and mech. experience, pwr. plants, concentrating and chemical plants, design and construction on pipe lines, pumps, conveyors, bldg. quarries, elec. mchy. repairing, pwr. plant and hydroelectric and pumping plant design and operation, steel drum mfg. equip., also teaching mech. engg. A-3651.

E.E. GRAD., 31, single, 9 yr. experience with elec. ry. Experience in executive and construction work. Desires connection with future. Available for work anywhere. D-643.

EXEC. ASST., tech. col. grad., 37, 12 yr. diversified experience in all branches of the utility business. Valuation work, rate investigation, cost analysis, statistical and financial research, engg. and sales work. Services offered to a company which can use to advantage a trained utility man. B-9782.

EXEC. ENGR., 41, M.E. and E.E. apprenticeship training. Mgmt. problems, industrial mfg. and utilities. Operation, design, and construction, mchy., pulp and paper, mining and concentration mills, elec., gas, water, and refrigeration system. Industrial engg. and cost accounting, production, waste-incentive system, reorganization work, scheduling, production, budgeting, sales. B-7944.

E.E. GRAD., 37, single, 15 yr. experience, covering pwr. station, substation, telephone equip., and elec. motor design, elec. motor, generator, and transformer test including development, mfg., and service test. 1 yr. postgraduate course on powr. factor, short-circuit, and transmission line calculation. Available now. Location, immaterial. D-637.

GRAD. ELEC.-MECH. ENG., 38, desires connection with utility or industrial firm on pwr. station operation as an engr. or asst. to an exec. 10 yr. experience in pwr. plant test, operation, design, construction, and maintenance. 3 yr. elec. engg. for industrial firms. 2 yr. asst. to pwr. engr. B-8379.

E.E., Univ. of Ill., 17 yr. experience covering design, construction, operation of steam, Diesel and hydro plants and elec. pumping stations. Records show lowered costs and improved service. Good organizer and economical. Fluent Spanish and French. D-660.

E.E. GRAD., 29, married, 7 yr. broad experience, pwr. house, substation, and transmission line design; major apparatus application, cost estimate, and equip. specifications. Excellent references. Desires connection with holding company, utility, or mfr. Location, South or East preferred. D-678.

E.E. GRAD., 1924, Univ. of Md., married, 8 yr. gen. experience in construction, design, and layout of substations for a large utility. Special experience in relay protection. Available in 6 wk. D-701.

E.E., 38, married, with 13 yr. experience signal and communication systems. Experienced inspection supervisor, methods engr., estimator, development and equip. engr.; 6 yr. experience as supervisor. 5 yr. tech. col. Available at once. C-2982.

E.E., 35, married, 3 yr. central station engg. proposals, sales construction. 7 yr. pwr. and industrial station wiring diagrams, conduit layouts, substation design, automatic, and supervisory equipments, rr. electrifications. Foreign languages. Available on short notice. Location, immaterial. D-710.

E.E. AND M.E. GRAD., married, 22 yr. experience, designing, construction pwr. plants, substations, transmission, distribution system, industrial plants. 3 yr. charge purchasing engg. equip., foreign interests. 3 yr. exec. experience charge engg. dept. large utility syndicate. Languages, English, German, Russian, Armenian, and Turkish. Available immediately. D-84.

GRAD. ENGR., 30, married, 2 yr. telephone switchboard testing, 1 yr. shop mech., 1 yr. municipal engg., 2 yr. designing and drafting for large copper smelter, last 3 yr. designing and drafting for large oil refinery. Desires position as asst.

to dept. head. Go anywhere. Pacific Coast preferred. C-4015.

E.E. GRAD., married, 37, wide experience in industrial plant elec. construction and maintenance; desires position in plant engg. with future. D-734.

TELEPHONE ENGR., 30, univ. grad., 10 yr. experience in design of outside plant, maintenance and specifications. Bell and independent experience. Successful in handling men. Desires opportunity with operating or holding company. D-736.

GRAD. E.E., 34, married, 10 yr. practical automotive maintenance. G.E. Test. 3 yr. designing industrial motors, d-c. arc welding equip. 3 yr. developing, designing transportation motors, control. 3 yr. automotive maintenance engg. with large bus, cab company. Interested in elec. automotive engg. D-95.

E.E., 33, married, desires position, mfr. of radio or public address systems, broadcasting station, or carrier dept. of elec. pwr. company. 4 yr. design, construction, operation, testing of equip. for elec. pwr. stations. 6 yr. installation, wiring, testing radio broadcast, tel. and tel. repeaters and carrier equip. Excellent references. D-733.

E.E. GRAD., 1924 M.I.T. cooperative, 30, married. G.E. Test; 5 yr. designing and application engr., ry. motors and equip., 2 yr. asst. to work-production mgr., in charge of all large apparatus contracts. Desire engg. or administrative position with mfr., utility or engg. firm, or teaching. Available immediately. D-760.

Foreman

FOREMAN OR CHIEF ELECTRICIAN, expert, armature winding, motor repairs, and trouble. Install wiring systems for light and pwr. Extensive practical experience. D-657.

Instruction

E.E. PROF., B.S. and E.E., 33, married, $2^1/_2$ yr. G.E. Co., 5 yr. with utility, 4 yr. teaching, 1 yr. as acting head of dept. Desires change. Location, South or Middle West preferred. C-7152.

DIRECTOR OF EDUCATION AND TRAINING with natl. tech. corp., formerly asst. prof. of E.E., B.S. and M.S. in E.E. Experienced in exec. and administration phases of educational work. Desires position as prof. or assoc. prof. of E.E. Location, immaterial. C-8967.

GRAD., E.E. 36, 8 yr. construction, maintenance large and small pwr. plants in this country and abroad. 4 yr. mech. production design including gas engines. At present doing grad. work Univ. of Calif. Desires instructorship, elec. mech. engg. with opportunity for research. Pacific Coast, South preferred. Available June. D-639.

E.E. GRAD., 28, married. B.S. Wash. Univ., desires position teaching mathematics, E.E. subjects or lab. work. 3 yr. design street lighting, 3 yr. selling elec. instruments and substation equip. Location, immaterial. D-688.

E.E. GRAD., 1929, single, 26, now attending leading eastern univ. working for M.S. in E.E. 15 months G.E. Test course including rectifiers, industrial control, research, ry. equip., motors, shop and elec. construction experience before graduation. Desires position, utility, mfg. or teaching. Available June. Will go anywhere in the U.S. C-9003.

GRAD. E.E., M.I.T. 1920, 35, married. Entire experience since then in E.E. teaching and industrial work. Good ability and personality. Desires work in E.E. teaching. Salary open. C-2826.

CORNELL GRAD., E.E. in 1929. Has had $2^1/_2$ yr. experience in design and manufacture of automatic temperature control equip. for oil refineries and regenerative furnaces. Some experience in tutoring and teaching. Desires position with mfr. of automatic control equip. or as an instructor in college. D-690.

PROF., ASSOC. PROF. E.E., 39, B.S. and E.E., Univ. of Colo. Practical experience with pwr., telephone, mining, and elec. mfg. concerns. 6 yr. on the E.E. faculty of state school. Now employed but available for school year. C-5021.

INSTRUCTOR OR ASST. PROF., 38, 8 yr. instructor in E.E., radio, physics in univ.; 5 yr. commercial experience, lighting, pwr., and radio installations, research, and design. At present research assoc. in physics in post grad. school of well known univ. Available for next September. C-6302.

DEAN OF ENGG. Mature engr.-teacher, 10 yr. experience, engg. faculties, followed by 15 yr. extensive experience engg. practise. Would consider position as dean of engg. in institution where recognition of present day needs, and ability to meet these needs is desired. Full details supplied, or personal interview arranged upon request. C-6733.

FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 yr. M.E. and E.E. grad. Allis-Chalmers designer and checker 5 yr., shop apprenticeship and miscellaneous experience, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

PROF., E.E., Ph.D., 44, 8 yr. excellent teaching experience as well as practical engg. experience. B-660.

GRAD., with Master's deg., 29, married, now substation design engr. for southwestern pwr. company. 5 yr. tech. experience, 7 yr. teaching experience in college physics and mathematics, desires teaching or research position. Best of references. Preferred location, Pac. coast, but any considered. Available on short notice. D-746.

E.E. GRAD., Midwestern col., 1931, single, 24, American. Excellent scholastic record. Desires teaching opportunity. Will teach E.E., mathematics, or mechanics. Location, immaterial. D-570.

INSTRUCTOR, now teaching engg. physics, wishes to locate with school or as private tutor for the summer. Permanent position would also be considered. Well versed in the practical side of engg., and in such extra-curricular subjects as photography, dramatics, and nature study. C-9916.

E.E. GRAD., 1929, G.E. Test experience including work in radio and vacuum tube engg. dept., and with all types of elec. mchy. Will receive M.S. this June. Desires a teaching or engg. opportunity. C-1879.

MECH.-ELEC. ENG. grad., 37, married, 10 yr. experience, design and maintenance of telephone and pwr. circuits with Western Elec. and operating companies. 4 yr. experience, teaching and research work in elec. engg. 2 yr. experience, sale of Diesel and Diesel elec. pwr. Location preferred, eastern. Salary open. Available immediately. C-6340.

Junior Engineers

1932 GRAD., 24, married. Wants a job now. Far West only. D-612.

E.E. GRAD., 1930, single, 24, 18 months G.E. Test and service shop experience. Some calculating and drafting. Good student record, ambitious, reliable. Desires position with utility or industrial concern. Prefer South West or Far West. Available immediately. D-628.

1931 E.E. GRAD., Clemson Agri. Col., 25, single, Desires work with utility, mfg. concern or construction corp. Available immediately. Location, immaterial. D-400.

E.E. GRAD., 1929, 25, single, $2^1/_2$ yr. experience in design and engg. of high tension outdoor and indoor substations. Desires position connected with hydroelectric development. Location desired, South. C-5967.

E.E. GRAD., 1931, Univ. of Wis., 26, single, 10 months' experience in utility construction; 2 yr. machine shop and garage. Interested in television. Location and salary immaterial. Available at once. D-640.

GRAD. E.E., 26, married, B.S. with honors 1930. 1 yr. experience with utility as a student cadet; 6 months' experience testing and treating boiler feedwater. Desires position with utility, operation or construction or with a radio mfg. company. D-673.

GRAD. E.E., Columbia Univ., 1932; single, 23, 4 yr. with research dept. of Bell Tel. Lab.; wishes to teach E.E. subjects, either full time, or part time, research or study, to obtain Master's deg. Location and salary immaterial. Available June. D-652.

GRAD. E.E., 1929, 8 months' G.E. Test, motors, generators, industrial control, vacuum tubes; 1 yr. inspection of engravings and electrotypes in pre-make-ready dept. of progressive publishing company, partly analysis. Vacation experience surveying transmission line and sewer construction. Desires work under engr. C-7975.

E.E. GRAD., June 1932, Georgia Tech, 24, single, experience in amateur radio, radio sales, and service, bookkeeping. Desires position in any E.E. field. Location, immaterial. Available after June 6, 1932. D-683.

E.E., grad. 1928, married, $3^1/_2$ yr. industrial testing experience, particularly in motor and control; also civil engg. and supervisory experience. Not afraid of responsibility. Desires a position with future. Location, immaterial. C-9568.

E.E. GRAD., 27, married. Design of pwr. plant, substation, and pwr. transmission lines. Industrial remote control. Also broad experience on appraisals of utilities. Available immediately. Location, immaterial. D-679.

E.E. GRAD., 1929, single, 23, 15 months student engr. on G.E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with a firm doing consulting or construction work or with utility or mfr. Available at once. Location, anywhere in U.S., New England preferred. C-8028.

GRAD. E.E., 22, single, Univ. of North Carolina, 1931. Extra study liberal arts and commerce schools. Desires position any engg. field, preferably telephone work. Four summers experience Ill. Bell Tel. Co., installation and maintenance. Salary immaterial at start. Any location either foreign or U.S. acceptable. Available immediately. D-527.

1931 GRAD. E.E., M.S. of large cooperative school, 24, single with dependents. Experience includes machine shop, drafting, clerking, armature winding, research assisting, and general maintenance and test experience with pwr. co. Desires position teaching elec. subjects, mathematics, mechanics, drawing or physics anywhere in U.S.A. Also interested in research. D-720.

GRAD. E.E., 1931, U. of M., single, 22, 7 months' student sales engr. Wagner E. Test; 9 months' experience elec., maintenance and construction of industrial equip., Ford Motor Co., 6 months' salesman. Desires position, elec. motor industry, or utility with opportunity for advancement. Location, Mich., and adjacent states preferred. Available immediately. D-719.

JR. ENGR., E.E. GRAD., V.P.I. 1930, 24, $1^1/_2$ yr. experience as utility engr. with large engg. corp. References. Desires connection with large mfg. plant, electrochemical corp. or utility corp. Anything considered. Available immediately, Location, immaterial. D-735.

1931 GRAD. E.E. from leading college in N. Y. State, 25, desires position in the elec. industry. Experience main motive. Several languages. Location U.S.A., foreign. Available immediately. D-164.

1931 E.E. GRAD. Mid-West univ., 23, single, 3 months' experience with large utility. Desires position with any mfg. firm or utility. Best of references. Location, immaterial. C-9984.

E.E. GRAD., 1931, cooperative, single, 25, American citizen. Tech. high school education in France. Fluent French; some German and Spanish. Experienced in radio and sound research. Training in pwr. and commercial engr. Available at once. Location, immaterial. D-743.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco	205 West Wacker Drive Chicago	31 West 39th St. New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

E.E. GRAD., Feb. 1932, Univ. of Mich., single, 24. Special training in illuminating engg., experience as electrician and contractor. Perfect knowledge of Russian and advanced German. Citizen of U.S. Salary and location immaterial. Available immediately. Recommendations. D-744.

E.E. GRAD., 23, Sc.M. M.I.T., Harvard 28; will receive Sc.D. M.I.T. June '32; single, 38; 8 yr. practical experience pwr.-business and communication engg.; 2 yr. testing course. Recently made valuable contribution to knowledge network synthesis.—Speaks Swedish, English, German. Reading knowledge French. Desires position, well-known organization preferably communication engg. Available. D-747.

GRAD. E.E., 24, single. Wants any position in a utility, with opportunity to prepare for advancement second in consideration to salary. Location, immaterial. Available immediately. Experience as meter tester, lineman, appliance sales and service man, draftsman, and asst. to dist. engr. C-9957.

E.E. GRAD., 1930 Columbia 6 yr. course, 25, single, 1 1/2 yr. with Paramount Publix Theatre Construction. Knowledge sound and projection equipment, drafting, supervision of construction and layout; instruments, foundry and pattern shop methods. Desires connection, any engg. capacity. Available immediately. Present location New York, but willing to go anywhere. C-7239.

GRAD., Mechanics Inst. 1926, 25, single. Experience. 1 yr. designing pwr. and substations; 3 yr. operation and control engr. utility; 2 yr. switchboard engr.; temporary position 5 months, elec. instructor, techn. school. Engg. or teaching position desired. Location, U.S.A. or Canada. D-741.

1931 GRAD., Brown Univ., experience in publication work, editorial and advertising. Good mgr. Stresses personal side of engg. Specialized knowledge of d-c. and a-c. mchy., transmission lines, auxiliary apparatus, testing, and application. General knowledge of drafting, hydraulics, mechanics, thermodynamics, and structures. Clever, industrious, and dependable. D-742.

E.E. GRAD., Univ. of Mich. 1930, 27, single, 2 yr. experience utility distribution engg., desires position in utility or engg. company. Available on short notice. Location, immaterial, domestic or foreign. D-740.

E.E. GRAD., 1930, 23, single, 15 months on G.E. Test, on ry. equip., rectifiers, industrial apparatus, industrial control, and refrigeration development. Desires position with utility or mfg. concern. Available at once. D-409.

E.E. GRAD., 1928, married, 29. Desires work on radio or photophone equip. Experience; 2 yr. installing and servicing X-ray and physical therapy equip.; 1 yr. research and development on speakers, auditorium, and photophone equip. with R.C.A. Victor Co. Prefer eastern or southern U.S. C-4220.

E.E., 27, 1 yr. practical experience, Westinghouse Co., testing motors, generators, transformers, steam turbines, relays, and control equipment; 3 yr. with a pwr. company, substation layouts, cost analysis, estimating, drafting, and development work. D-748.

E.E. GRAD., Univ. of Ill., single, 22. Excellent scholastic record. Experience in utility engg. and in control research and design. Good references. Available immediately. Any location. D-759.

M.E. GRAD., Stevens Inst. of Tech., 24, single, 8 yr. in elec. work for light and pwr. of all descriptions. Also communication knowledge with experience. Location, immaterial. C-9976.

Maintenance and Operation

E.E. GRAD., married, 28, with wide experience in industrial plant elec. construction and maintenance; ry. electrification; pwr. plant design, estimating, and supervisory construction experience with elec. contractor; cost analysis. Desires position with future. C-4428.

GRAD. ENGR., 32, married, 1 yr. telephone engg.; 5 yr. construction, operation, test and maintenance of underground transmission, and distribution cable and equip.; 3 yr. transmission and distribution engg. D-623.

COMMUNICATION ENGR. Broad theoretical experience telegraph, telephone, radio, etc., design, installation and maintenance. Many years foreign service. Available U.S. or abroad on short notice. C-8805.

E.E. GRAD., 1928, 6 yr. hydro and steam plant elec. operation and maintenance; 5 yr. office and cost accounting, expert stenographer and bookkeeping. Desires position with utility or mfg. concern in any part of U.S. or foreign. C-7796.

Production

INDUSTRIAL ENGR., E.E. grad., 28, married. Now employed by large mfr. of elec. equip.; 2 yr. experience test engr.; 4 yr. wage incentive installation, including job analysis, methods engg., time study, cost control, and supervising wage system operation. Excellent references. D-737.

Research

E.E., B.S., E.E., 28, single. Experience: Testing a-c. and d-c. machines in process of construction. G.E. Test course. Drafting, designing of elec. testing equip. Developmental work on instruments and instrument transformers. Work preferred: Development, layout, installation, maintenance of plant equip. in industrial pwr. company. Location preferred: East, Middle West. D-726.

JR. ENGR.-STATISTICIAN: B.S. in E.E. 1930, 25, single, 1 1/2 yr. statistical and economic research experience. Thorough tech. and business training. Speaks Spanish fluently. C-7551.

Sales

E.E. GRAD., 1929, 27, single, 2 yr. exceptional experience as jr. engr. with pwr. co. including commercial, engg., construction, and pwr. plant, 1 yr. experience pwr. sales and industrial engg., Desires position preferably in pwr. sales or industrial engg. Excellent references. Location, South preferred. Available at once. D-605.

SALES MGR., ENGR., 35, experienced capable sales contact man, desires connection as representative or mfr. agt. with high grade company mfg. line of high or low voltage equip. for utilities or industrial plants. B-4067.

SALES ENGR., grad. E.E., 33, married. Excellent background of sales and adv., desires connection with mfr. Location preferred, Middle West. Experience in industrial adv. in addition to engg. and selling of elec. equip. Excellent references. B-8614.

SALES ENGR., single, grad. Kansas Univ. '29. G.E. Test course including photophone, radio, industrial control, motors, transformers, and quotation work; 8 months engg. street ry.; 5 months sales engg. with large dealer in new and rebuilt elec. mchy. Now employed. D-674.

ENGR. (British) now engaged, desires correspondence with mfr. in U.S. desirous of establishing branch industries on other side. Also familiar with Canadian, Indian, and African conditions. D-699.

SALES ENGR., E.E. grad., 30, married, 1 yr. testing and engg. western utility; 2 yr. testing; 4 1/2 yr. design, application, and sales engg. with G.E. Desires permanent connection engg. or sales dept. with utility or mfr. Available at once. New York State or East preferred. D-696.

SALES ENGR., col. grad., 36; G.E. Test (steam and elec.) also factory and district office sales experience. For last few years employed as senior industrial engg. representative (elec.) with outstanding central station company. Would like new affiliation preferably in the East. C-5618.

SALES ENGR. OR MFRS. AGT., grad. E.E., 32, over 5 yr. utility in construction, maintenance, and design, over 3 yr. as sales engr. for elec. mfr., including about 3 yr. as jr. exec. Location, immaterial for salary position. Pittsburgh headquarters as mfrs. agt. D-745.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Berry, Wayne J., c/o Genl. Elec. Co., Schenectady, N. Y.
Bugg, Vernon, 736 Transportation Bldg., Washington, D. C.
Du Rieu, E. F., c/o Tate & Hays, 341 Madison Ave., N. Y. City.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Miyamoto, Tatsuo C., 1330–4th St., Sacramento, Calif.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Ness, L. G., 2105–6 Sterick Bldg., Memphis, Tenn.

Membership

Applications for Election

Applications have been received by the secreatry from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the assistant national secretary before May 31, 1932.

Anderson, C. J., Barber-Colman Co., Rockford, Ill.
Bailey, R. S., Kansas Gas & Elec. Co., Wichita (Applicant for reelection)
Caldwell, C. W., Univ. of South Dakota, Vermillion
Colclough, O. T., Consumers Pwr. Co., Muskegon Heights, Mich.
Cordray, R. E., Genl. Elec. Co., Phila., Pa.
Cotter, M. T., 1001 W. Clay St., Ukiah, Calif.
Dilley, M. M., Automatic Safety Signal Gate Co., Louisville, Ky.
Dumelow, L. S., 34 Church St., Alton, R. I.
Elley, A. C., Yates-American Machine Co., Beloit, Wis.
Fields, C. W., Jr., New York & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.
Gibson, N. R. (Member) Buffalo, Niagara & Eastern Pwr. Corp., Buffalo, N. Y.
Gray, T. J. (Member), Pub. Serv. Co. of Colo., Fort Collins
Guptill, C. F., United Electric Lt. & Pwr. Co., N. Y. City
Harvey, J. H. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Hildebrand, A. M., Lake Erie Pwr. & Lt. Co.; Lake Shore Elec. Ry. Co., Sandusky, Ohio
Horton, H. M., Okla. Gas & Elec. Co., Okla. City
Jelinek, U., 132 Smith St., Elizabeth, N. J.
Kersten, A. W., Wisconsin Tel. Co., Milwaukee
Klaus, C. E., Westinghouse Elec. & Mfg. Co., Portland, Ore.
Kolks, R. H., Union Gas & Elec. Co., Cincinnati Ohio
Leha, H., 1369 Freemont Place, Elizabeth, N. J.
Litchfield, W. L., 28 Spring St., Danbury, Conn.
Mansfield, W. A. Conduits Co., Ltd., Toronto, Ont., Can.
May, R. W., Dept. of Public Works, N. Y. City
McTwiggan, T. L., 130 Rich Ave., Mt. Vernon, N. Y.
Michel, C. B., Bell Tel. Co. of Pa., Philadelphia
Milligan, J. W. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Niemann, W. H., Intl. Time Recording Co., San Antonio, Tex.
Rosecky, J. J., Univ. of Wisconsin, Madison
Rote, F. J., Brooklyn (B. Y.) Edison Co., Inc.
Rowe, W. H., Genl. Elec. Co., Lynn, Mass.
Sykes, W. E., Bell Tel. Co., Toronto, Ont., Can.
Tweedle, C. E., L. S. Vallely & Co., Houston, Tex.
Webb, R. B., Southwestern Bell Tel. Co., Dallas, Tex.
Weil, C. R., Gould Storage Battery Corp., Depew, N. Y.
35 Domestic

Foreign

Ali, S. N., H. H. Government, Patiala State, Punjab, India
Crisp, H. K., Municipalities of Bowral and Mittagong and Shire of Nattai Bowral, N. S. W., Australia
Gokli, K. N., R. Gokli & Co., Matunga, Bombay, India
Gomez, A., Chilean State Rys., Valparaiso, Chile, So. Am.
Perry, A. M., Hachbridge Elec. Construction Co., Surrey, England
5 Foreign

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during March are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES de Chimie, de Physique, de Biologie et de Technologie, v. 8, 1927–8, Pt. 1. Paris, Gauthier-Villars et Cie; N. Y., McGraw-Hill Book Co., 1931. 1101 p., 11x9 in., cloth, $10, Pt. 1.—Presenting a year by year compilation of the numerical constants and data that have appeared in the important scientific periodicals. The present part covers mechanics, heat, light, electricity, and magnetism. Titles and explanatory matter are given in English as well as in French.

ADVANCED ELECTRICAL MEASUREMENTS. By W. R. Smythe and W. C. Michels. N. Y., D. Van Nostrand Co., 1932. 240 p., illus., 9x6 in., cloth, $3.00.—Intended for training in the use of research methods and instruments and testing, and development work; a course given to senior students at the California Institute of Technology. Standard electrical measurements are included; also methods for measuring temperature, radiation, and other quantities not primarily electrical. The theory of each method is discussed, and references for further reading provided.

APPLICATIONS OF REFRIGERATION. Book I. By C. T. Baker and I.C.S. Staff. Scranton, Pa., Intl. Textbook Co., 1929. 44 p., illus., 8x5 in., cloth, $1.25.—A description of the principles and construction of the most popular types of refrigerating machines. Automatic for commercial and domestic use.

ARTIFICIAL LIGHT AND ITS APPLICATION IN THE HOME. By the com. on res. ltg. of the Illum. Engg. Soc., Mariquita Dygert, Chmn. N. Y. & Lond., McGraw-Hill Book Co., 1932. 145 p., illus., 9x6 in., cloth, $1.50.—A concise, practical book on the lighting of residences, prepared by a group of authorities and endorsed by the Illum. Engg. Soc. Primarily a text for students of home economics, but also of use to housewives in search of simple, reliable information on artificial lighting.

BOOK OF METALS. By D. Wilhelm. N. Y. & Lond., Harper & Bros., 1932. 341 p., illus., 10x7 in., cloth, $4.00.—A story of industrial metals, their history, mining, refining, alloying characteristics, and uses. Breezy and popular, but read and accuracy approved by acknowledged authorities. For needs of general information on the metals.

DIE ELEKTRISCHE FERNÜBERWACHUNG UND FERNBEDIENUNG FÜR STARKSTROMANLAGEN UND KRAFTBETRIEBE. By M. Schleicher. Berlin, J. Springer, 1932. 238 p., illus., 9x6 in., 21 rm.—Remote control and supervision of machinery and power methods are presented systematically. Calling attention to underlying principles and fields of usefulness rather than to details of instruments. Remote meteiing, signaling, and control are considered. Bibliography.

DYNAMICS OF ENGINE AND SHAFT. By R. E. Root. N. Y., John Wiley & Sons, 1932. 184 p., illus., 9x6 in., cloth, $3.00.—For 12 years Prof. Root has given a course at the postgraduate school, Naval Academy upon this subject, and the results of his experience appear in this brief textbook. It aims to present methods for evaluating the forces that operate in a reciprocating engine, to trace their effects in turning moment on the shaft and in bearing pressures, and to reveal their significance in relation to vibrations. The book also treats of torsional and transverse vibrations of elastic systems and discusses critical speeds.

FREILEITUNGSBAU MIT SCHLEUDERBETONMASTEN. By L. Heuser and R. Burget. München & Berlin, R. Oldenbourg, 1932. 176 p., illus., 10x7 in., paper, 10 rm.—A comprehensive account of the history and construction of the hollow concrete pole and its use for overhead electric lines. Discusses design and testing of poles, transport and erection, costs, and applications to power, telephone, and telegraph networks. Includes table of all the European lines on concrete poles.

GENL. ENGG. HANDBOOK. Edited by C. E. O'Rourke and others. N. Y., McGraw-Hill Book Co., 1932. 921 p., illus., 8x5 in., leath., $4.00.—In preparing this compendium of engineering data, attempt has been made to compress the important fundamentals of engineering into a single small volume which will supplement detailed handbooks devoted to one field. Divided into 31 sections, six devoted to subjects of interest to all engineers. The remainder treat the major branches of civil, mechanical, and electrical engineering. Each section by an expert in its field.

HANDBOOK OF BUSINESS ADMINISTRATION. W. J. Donald, ed. N. Y. & Lond., McGraw-Hill Book Co., 1931. 1753 p., illus., 7x5 in., leath., $7.00.—An encyclopediac presentation of current practise in all departments of business, prepared specialists and sponsored by the Am. Mgmt. Assn. Marketing, financial production, and office management; personnel and gen. mgmt. are discussed in all ramifications. A concise, handy summary of the policies of many business leaders.

JOBS, MACHINES, AND CAPITALISM. By A. Dahlberg. N. Y., Macmillan Co., 1932. 252 p., illus., 8x6 in., cloth, $3.00.—The author believes that capitalism as a system of economy has not had a fair trial and that under certain conditions it can secure all and more than communism, while avoiding the major difficulties and evils of the latter system. The evils of capitalism would disappear, he believes, were it forced to work under a chronic scarcity of labor rather than a chronic scarcity of job and business opportunity. A method for accomplishing it is suggested.

LEHRBUCH DER RADIOAKTIVITÄT. By G. v. Hevesy and F. Paneth. 2. Auflage. Leipzig, J. A. Barth, 1931. 287 p., illus., 9x6 in., paper, 22 rm; bound, 24 rm.—The aim of the authors of this work has been to supply a text-book concisely covering the whole field of radio-activity, in which due attention is paid both to its physical and chemical aspects; its relations to other branches of science are indicated. Revised and partly rewritten.

LUFTBEHANDLUNG IN INDUSTRIE— UND GEWERBEBETRIEBEN. By L. Silberberg. Berlin, J. Springer, 1932. 174 p., illus., 10x6 in., cloth, 18 rm.—On air conditioning; intended to provide an account of current practise for engineers and factory owners. An introduction devoted to scientific principles, the technique of air conditioning is discussed at some length. The solution of problems involved, and the apparatus used are considered, with advice on systems and operating costs.

MANUAL OF ELECTRIC ARC WELDING. By E. H. Hubert, ed. N. Y. & Lond., McGraw-Hill Book Co., 1932. 163 p., illus., 9x6 in., cloth, $2.00.—Explains the fundamentals of arc-welding processes, with practical suggestions for performing various welding operations and many uses of arc welding. Clear and full, presenting main facts. Sponsored by the welding section of the Natl. Elec. Mfrs. Assn.

MATHEMATICAL TABLES, v. 1. Circular and hyperbolic functions, exponential sine and cosine integrals, factorial (Gamma) and derived functions, integrals of probability integral. Lond., British Assn. for the Advancement of Science, 1931. 35 p. text + 72 p. tables, 11x9 in., cloth, 10s.—For over fifty years the British Assn. for the Advancement of Science has published from time to time mathematical tables in its reports. A selection of these now appears in revised and extended form in this volume. The tables are indicated by titles, most of them extend to twelve or fifteen decimals and include facilities for interpolation. Construction explained in the introduction. The page is large and open and the type clear.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Bd. 1, Heft 9, p. 201–24, Jan. 1932. Berlin, VDI-Verlag, illus., 12x9 in., paper, 2.70 rm.—The subjects discussed are: the considerations governing the choice between private and public electric plants, the economical use of rotary well drilling plants, the sustained tractive power of Diesel automobile engines, and the determination of the speed and acceleration of valves of high-speed internal-combustion engines.

MOTORBUS TRANSPORTATION. 4 v. By I.C.S. Staff. Scranton, Pa., Intl. Textbook Co., 1931. illus., 8x5 in., cloth, Book 1, $1.75; Book 2, $1.25; Books 3 & 4, $1.00 each.—Volumes cover the subject concisely yet comprehensively. The organization of bus companies, laws relating to them, operators, financial problems, equipment, maintenance, management, and other important topics are considered, and current practise in these matters is indicated.

NATL. ELEC. CODE HANDBOOK. By A. L. Abbott. N. Y., McGraw-Hill Book Co., 1932. 473 p., illus., 8x5 in., leath., $3.00.—This book is intended as a reference book for users of the Code and a text-book for a systematic study of it. Rules are grouped in a way to enable all applying to a given device or method to be found at once, their meaning clarified by comments, explanations, and diagrams.

PATHWAYS BACK TO PROSPERITY. By C. W. Baker. N. Y. & Lond., Funk & Wagnalls Co., 1932. 351 p., 8x6 in., cloth, $2.50.—A well-known engineer and economist analyzes the underlying causes of the economic and social difficulties of today and points out the paths to renewed prosperity. He finds chief requirement a more general distribution of wealth.

PHOTOELECTRIC PHENOMENA. By A. L. Hughes and L. A. Du Bridge. N. Y. and Lond., McGraw-Hill Co., 1932. 531 p., 9x6 in., cloth, $5.00.—This work aims to provide a concise, yet comprehensive critical survey of the whole field of photoelectric phenomena. The present status of the three major branches of photoelectricity, surface, volume, and photovoltaic effects is summarized; fundamental laws, their experimental bases, and theoretical significance are discussed, and their practical applications briefly reviewed. No formal bibliography, but ample bibliographic footnotes.

PROFITABLE PRACTISE IN INDUSTRIAL RESEARCH. Edited by M. Ross, M. Holland and W. Spraragen, prepared under the auspices of the Natl. Research Council. N. Y. & Lond., Harper & Bros., 1932, 269 p., 9x6 in., cloth, $4.00.—A symposium by the directors of some of the greatest industrial research laboratories of the country. The philosophy and practical application of industrial research, the organization of research departments, the selection of research workers, research work in foreign countries, the part played by trade associations, the government and universities, and the transference of the results of research to the factory all are discussed.

REWINDING DATA FOR D-C. ARMATURES. By G. A. Van Brunt and A. C. Roe. N. Y., McGraw-Hill Book Co., 1932. 212 p., illus., 9x6 in., cloth, $2.50.—Gives practical directions for taking and recording, in a uniform, systematic manner, the information for repairing these armatures. Also the rules governing the various types and windings, and chapters devoted to materials, insulation, banding, dipping and baking. Several chapters on "frog-leg" windings. Expanded from articles that appeared in "Maintenance Engineering."

STANDARD WIRING FOR ELEC. LT. AND PR. By H. C. Cushing, Jr., 38 ed. N. Y., H. C. Wushing, Jr., 1932. 488 p., illus., 7x4 in., leather, $3.00.—A new edition of a well-known guide like its predecessors sets forth clearly and fully the essential requirements for safe and efficient wiring and construction and the latest engineering practise. Complies with Natl. Electric Code.

COLOUR SCIENCE, Part 1. By W. Ostwald. Authorized translation with introduction and notes by J. S. Taylor. The April issue of ELECTRICAL ENGINEERING gave the address of the publishers, Winsor & Newton, Ltd., as London. They are of London and New York.

Engineering Societies Library

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Industrial Notes

Multiple "V" Belt Patent Suit Settled.—The Allis-Chalmers Manufacturing Company announces that the suit between it and the Dayton Rubber Manufacturing Company, of Dayton, Ohio, in the United States District Court at Cincinnati, involving patent infringement of Allis-Chalmers Geist patent No. 1,662,511 pertaining to multiple "V" belt drives has been settled out of court. The Dayton Rubber Manufacturing Company takes a license under the Geist patent and the Allis-Chalmers Manufacturing Company has the right to operate under Short patent No. 1,538,303, if it so desires.

Corning Glass Appoints Insulator Representatives.—The following appointments have been announced by the Corning Glass Works, Corning, N. Y., of representatives for the sale of "Pyrex" power insulators: J. E. Redmond of Phoenix, Arizona, for Arizona, New Mexico, and the El Paso district of Texas; J. Q. Lalor, Denver—Colorado and Wyoming; L. B. Graves, Minneapolis—North and South Dakota, Wisconsin, and Minnesota; A. J. Heisel, New Orleans—Mississippi and Louisiana; Wise & Braisted, Detroit—Michigan.

Norma-Hoffmann Moves New York Sales Office.—Announcement has been made by the Norma-Hoffmann Bearings Corporation, manufacturers of "Precision" ball, roller, and thrust bearings, that its New York sales office has been moved from the Grand Central Terminal to new and larger quarters in the Commerce Building, 155 East 44th Street. A full staff of sales engineers with increased facilities will continue to serve the Eastern territory.

New Double Row Ball Bearing.—The Federal Bearings Company, Inc., Poughkeepsie, N. Y., announces the introduction of a series of double row, self-aligning radial ball bearings, available in all popular sizes. One of the important features of this series is a separate ball spacer or retainer for each row of balls. This is particularly advantageous when bearings are used under conditions where the self-aligning feature is frequently brought into use. This flexible retainer absorbs much of the severe strain to which retainers in self-aligning bearings are usually subject.

A New Electrographitic Brush.—The National Carbon Company, Inc., Carbon Sales Division, Cleveland, announces a new electrographitic brush known as National Pyramid Grade No. 234. A unique characteristic is the non-resilient structure, enabling the brush to maintain exceptionally firm contact on commutators of high peripheral speed. It is claimed that excellent commutation, low friction and high carrying capacity combine with the smooth riding properties of this new grade to minimize brush wear and commutator maintenance. The new brush is designed especially for heavy duty, d-c. generating and substation equipment.

Surge Diverters for Distribution Transformers.—Coordination of the transformer insulation so that the bushing will flash over before the windings fail, gives "surge-proof" characteristics to a transformer, but naturally, when the bushing flashes over, a power arc may follow of sufficient magnitude to blow the primary fuses, according to the Allis-Chalmers Mfg. Company, Milwaukee, Wis., which announces surge diverters for application with their distribution transformers to eliminate this effect. The surge diverter has been designed to function in less than 50 microseconds so that it can be connected between the primary fuses and the transformer. This rapid action does not give time for the fuse to operate so that fuse blowings are minimized. Surge diverters may be installed outside or inside the transformer case. The flexibility in mounting makes it possible to connect the diverter either to separate ground connections or to secondary neutrals as desired.

Trade Literature

Instrument Transformers.—Catalog GEA 601D, 52 pp. Describes standard lines of GEA switchboard and portable transformers; includes dimensions. General Electric Company, Schenectady, N. Y.

Groundometers.—Bulletin 120C, 8 pp. Describes various types of ground testing instruments, each designed for a particular class of testing. Borden Electric Company, 480 Broad Street, Newark, N. J.

Distribution Transformers.—Bulletin 8248-A. Describes a new distribution transformer which will not be injured by lightning surges entering either the primary or secondary windings. Westinghouse Electric & Mfg. Company, Sharon, Pa.

Magnetic Across-the-Line Switches.—Bulletin GEA 1568. A complete treatment of G-E control equipments of this type for every service in all sizes up to 1200 hp.; explosion-proof, oil-immersed, etc. General Electric Co., Schenectady, N. Y.

Lightning Arresters.—Bulletin 1, 8 pp., the first of a series describing crystal valve lightning arresters for high and low voltage transmission and distribution circuits, and for telephone and telegraph lines. Electric Service Supplies Co., 17th and Cambria Streets, Philadelphia, Pa.

Cements and Compounds.—Bulletin 32, 16 pp. Describes a line of cements and industrial compounds for acid-proofing, surface coating, impregnating, oil resisting, electric insulation, repairing, etc. Technica Products Company, Pittsburgh (Sharpsburg Station), Pa.

Insulating Oil Purifiers.—Bulletin, 20 pp. Describes the "Buckeye" hydro-volifier for purifying insulating oils. Analyses of insulating oils as contaminated by various uses and their purification by the vacuum treatment with the hydro-volifier are outlined. The Buckeye Laboratories, Inc., 510 West Ely Street, Alliance, Ohio.

Radio Transformer.—Bulletins 121A, 122 and 123. Describe Acme step down transformers, replacement transformers, and power transformers, respectively. These products are made principally in large quantity production for radio and allied manufacturers. The Acme Electric & Mfg. Company, 1444 Hamilton Avenue, Cleveland, Ohio.

Small Rotary Converters.—Bulletin and price list, 8 pp. Describes new, improved "Martin" interpole, alternating current to direct current, ball bearing rotary converters, with panels and resistances, for motion picture and general theatre use. Northwestern Electric Co., 418 South Haynes Avenue, Chicago, Ill.

A-C. Rectifier Power Packs. Bulletin, 4 pp. Describes "Rectopacs"—complete d-c. power packs for industrial applications to operate from a-c. lines. These B-L rectifier assemblies are used in the operation of signal systems, magnets, relays, control equipment, low voltage motors, battery charging, etc. B-L Electric Mfg. Co., 19th & Washington Ave., St. Louis, Mo.

Power Factor Correction.—Bulletin. Describes how power factor may be corrected through the use of static condensers in convenient unit form, assembled and mounted to meet any requirements. The bulletin contains an ingenious scale whereby the condenser capacity required for any given power factor correction may be instantly determined. Dubilier Condenser Corporation, 4377 Bronx Blvd., New York.

Testing Machines.—Catalog 50H, 116 pp. Describes Olsen testing and balancing machines and instruments. Such equipment is made for numerous purposes including tests for endurance, fatigue, hardness, flexibility, etc., of materials. Static and dynamic balancing machines are used by manufacturers of motors and turbines for determining armature and rotor balance. Tinius Olsen Testing Machine Co., 500 North 12th Street, Philadelphia, Pa.

Insulators.—Catalog 32, 320 pp. This volume is described as a handbook of reliable information for those interested in modern methods of high voltage transmission. The catalog includes illustrations, cross sections and specifications of Locke insulators. Methods of manufacture are depicted, and the history of the Locke grading shield is outlined. Included are the A.I.E.E. and NEMA Standards for insulator tests; also wire and cable tables. Locke Insulator Corporation, So. Charles & Cromwell Streets, Baltimore, Md.